# SCIENTIFIC AMERICAN SUPPLEMENT. No. 1590

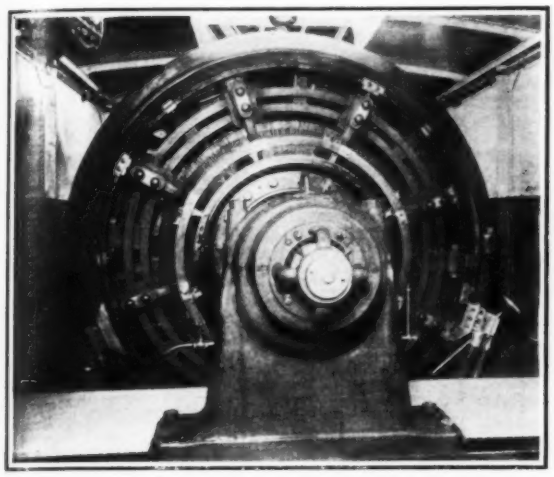
Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1906, by Munn & Co.

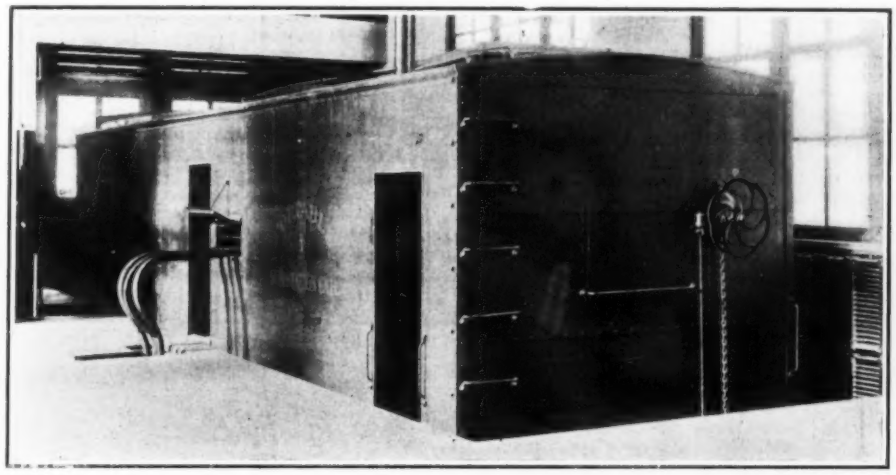
Scientific American, established 1845.
Scientific American Supplement, Vol. LXI., No. 1590

NEW YORK, JUNE 23, 1906.

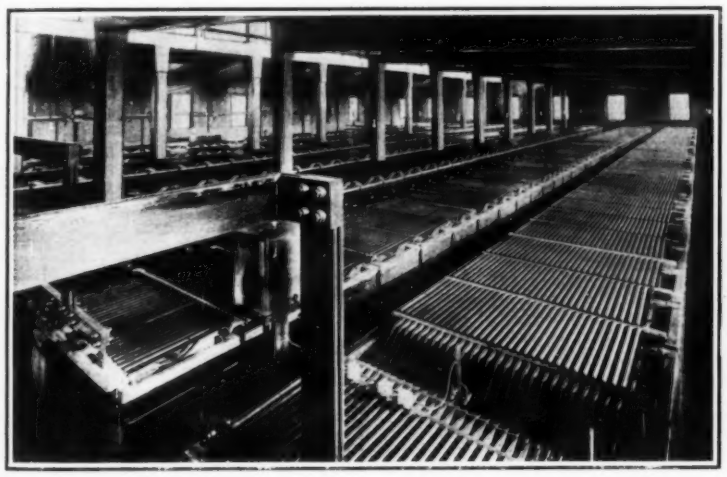
Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

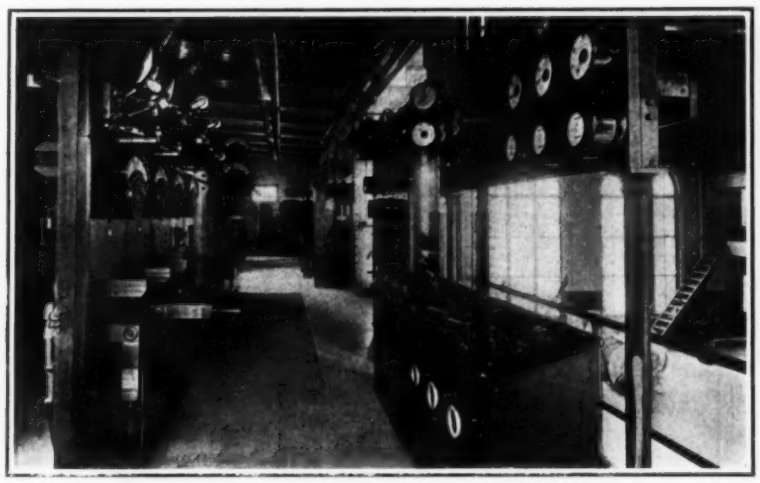
ROTARY CONVERTER IN PORTABLE SUB-STATION.



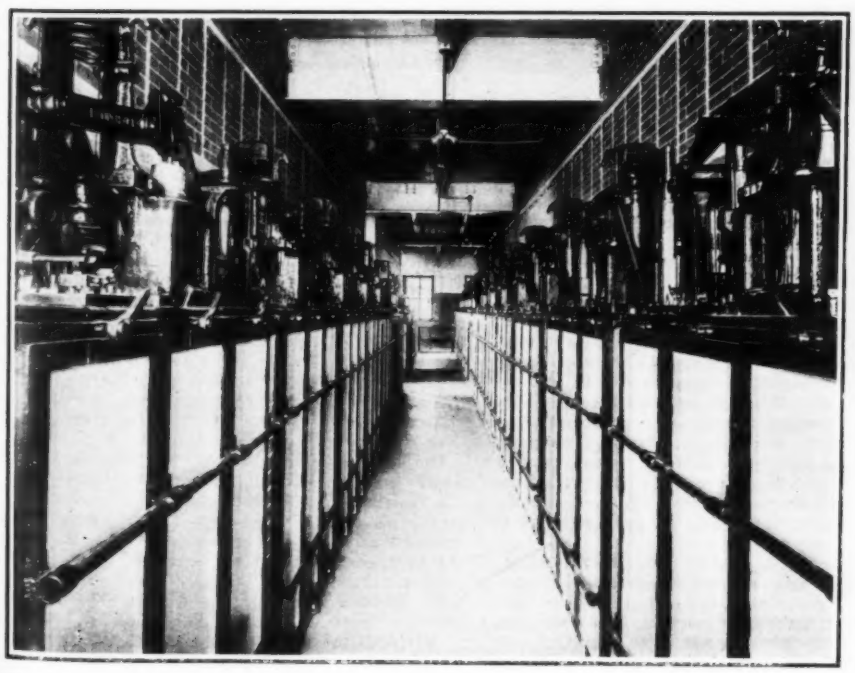
PORTABLE SUB-STATION CAR CONNECTED UP AT ROCKAWAY JUNCTION.



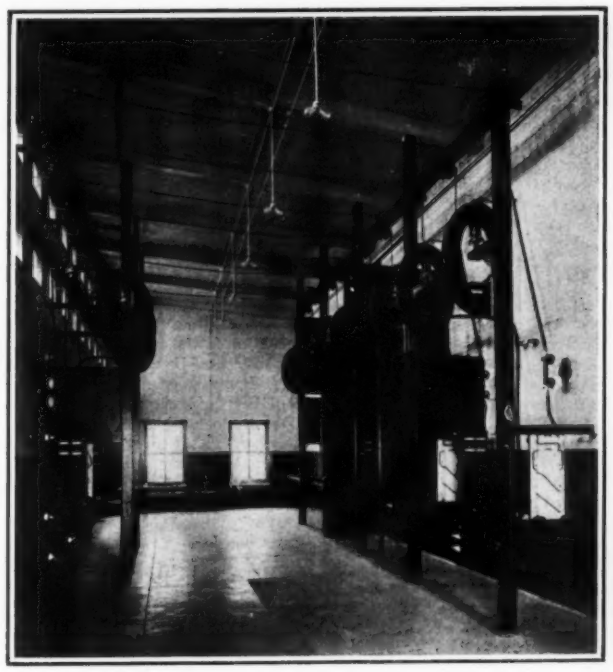
THE BATTERY ROOM OF HAMMEL SUB-STATION.



OPERATING GALLERY AT WOODHAVEN JUNCTION.



HIGH-TENSION SWITCH GALLERY AT WOODHAVEN JUNCTION.

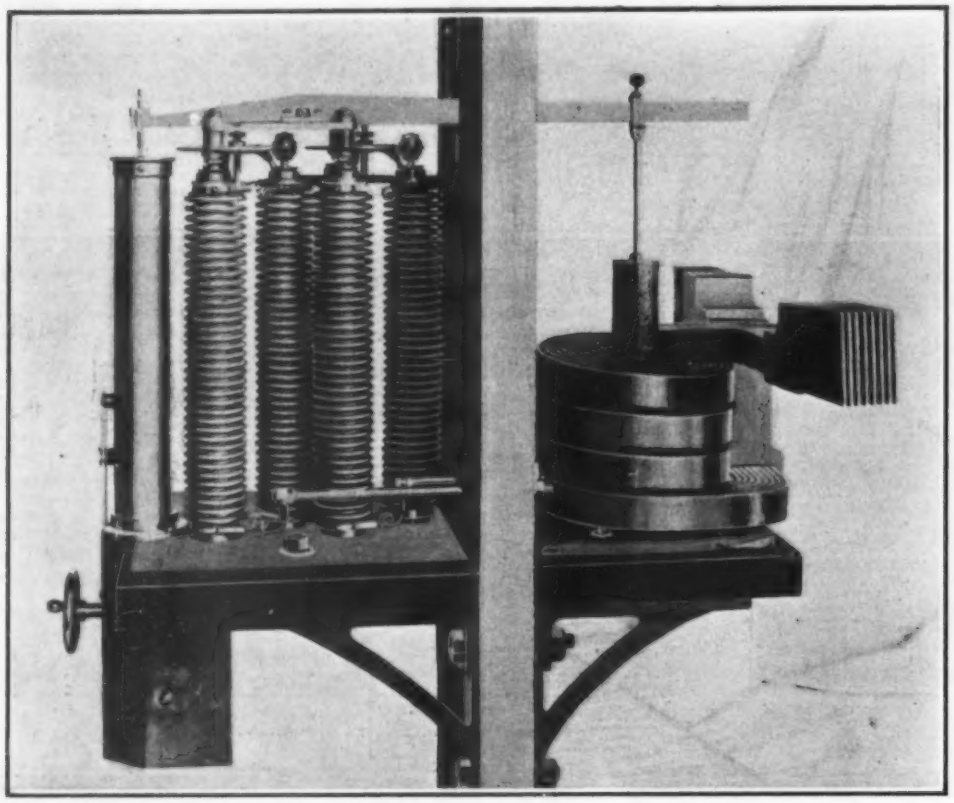


LIGHTNING ARRESTER GALLERY AT ROCKAWAY JUNCTION.

ROTARY CONVERTER SUB-STATIONS OF THE LONG ISLAND RAILROAD.

## ROTARY CONVERTER SUB-STATIONS OF THE LONG ISLAND RAILROAD.

IN the SCIENTIFIC AMERICAN of June 9 we published a description of the power-transmission system of the Long Island Railroad. The present article on the rotary converter sub-stations of the Long Island Railroad will, therefore, serve to supplement the previous article. In the former article it was noted that the Woodhaven Junction served as the natural geographical center of the district to be equipped, and it was, therefore, made the chief distributing station. Aside from this sub-station there are four others ranging from three to seven miles distant from the distributing point, and two portable sub-stations. The construction of the sub-station buildings is similar in most respects, except that where underground circuits are used, as is the case at East New York and at Hammel, there are but two floors in the high-tension gallery. At Woodhaven and Rockaway Junction, however, where overhead circuits are employed, a third story is added to the high-tension gallery, which serves the double purpose of affording a convenient entrance to the building for the cables about on a level with the cross-arms, and at the same time provides a suitable chamber for inclosing the high-tension lightning-arrester apparatus. Each sub-station is served by a 16-ton crane, hand-operated from its trolley, thus obviating the usual hanging chains. It spans the central bay, and is available not only for handling the permanent heavy sub-station machinery, but also the apparatus of the portable sub-stations, which (excepting at Grand Avenue) can be run under it upon the track that enters one of the end bays of the building.



CARBON REGULATOR FOR STORAGE BATTERY.

The portable sub-stations are made necessary by the periodic race-track traffic, which occurs only twice a day for four weeks in the entire year. Each of these sub-stations consists of a 1,000-kilowatt rotary converter with transformers, switchboard apparatus, and the necessary auxiliaries carried in a heavy steel car resembling a freight car in general appearance. The end of the car containing the rotary converter is so built that it can be readily taken to pieces and, in fact, entirely knocked down, so that the rotary converter can be easily taken apart, if necessary, by being run under the crane in any of the sub-stations. As there is but one race track in operation at a time, both of the portable stations are used, first at one track, and then at the other. While being used the cars are housed in buildings especially designed to accommodate them. One of these buildings is located at Belmont Park, and the other at Springfield Junction.

The Woodhaven Junction sub-station, owing to its central position, is installed with heavier machinery than the other sub-stations. Its present installation consists of three 1,500-kilowatt rotary converters, and ultimately it will have a capacity of six 1,500-kilowatt rotary converters. The other stations are at present equipped with 1,000-kilowatt rotary converters.

The 1,000-kilowatt rotaries are rated to deliver 1,600 amperes at 625 volts, and 1,667 amperes at 600 volts. The 1,500-kilowatt rotaries are rated to deliver 2,400 amperes at 625 volts, and 2,500 amperes at 600 volts. In nearly all respects the two sizes of machines are very similar. The fields are compound-wound, with the shunt winding arranged for self-excitation. The machines are so over-compounded that, if operated as direct-current generators, at constant speed, the voltage will rise from 600 volts at no load to 650 volts at full load. The machines will operate for twenty-four hours continuously at full load, with a temperature rise not exceeding 40 deg. Centigrade; at 25 per cent overload they will operate for twenty-four hours, with a rise of not more than 50 deg.; while at 50 per cent overload they will operate for three hours, with a rise of not more than 60 deg. Centigrade in any part. They have frequently commutated momentary overloads of 150 per cent in actual service, without injurious sparking and without the necessity of shifting the brushes. The transformers used with the converters are of the air-blast type throughout. Those for the 1,000-kilowatt rotaries are grouped in banks of three 375-kilowatt transformers to one rotary converter. For the 1,500-kilowatt converters they are in groups of three, 550 kilowatts each. In each station there are four sets of auxiliary transformers, which supply current for the rotary converter starting motors, the motors driving the booster generators and their exciters, the transformer blower motors, and for house lighting.

At Hammel, which is farther from the power station than any of the other sub-stations, and, by reason of the exposed position of the transmission line running across Jamaica Bay, might be considered somewhat more liable to interruption in service through accident to the transmission, a storage battery is installed. The marked fluctuations in load at this point, due to heavy travel to Rockaway Beach on summer afternoons and evenings, afford a better opportunity than almost any other location for testing the general applicability of the battery. The station load in the winter season is extremely light, and this fact enables it to be operated for much of the time from the battery alone. The storage battery equipment consists of 300 cells of 3,200-ampere capacity and two boosters of 162-kilowatt capacity each. In cases of necessity the battery has sufficient capacity to discharge at the rate of 6,400 amperes for a space of twenty minutes, and for instantaneous fluctuations it can discharge up to a momentary maximum rate of 9,600 amperes, or three times the normal one-hour rate. The boosters consist of one three-phase induction motor and one direct-current generator mounted on a common bed-plate. The booster generator is rated to deliver 1,200 amperes at 135 volts continuously, with a rise of temperature not to exceed 40 deg. Centigrade above the temperature of the surrounding air. It has an overload capacity of 1,600 amperes for one hour, and 3,200 amperes for two minutes. Two of these boosters in parallel are required to take advantage of the full discharge rate of the battery. It was thought desirable to split the booster capacity, so that in case of accident to the booster the whole battery capacity of the station would not be tied up by the failure of a single booster unit.

In order to use the battery to maintain a comparatively steady load on the rotary converters, the boosters which are in series with the battery and the third rail circuit must have their magnetic field excitation changed, both as to intensity and as to polarity, by an amount that will cause the boosters to either charge the battery from the rotaries, or when reversed to discharge it into the third-rail circuit; and this must be effected as nearly as possible instantaneously with the fluctuations as they occur in the system. The intensity of the booster field is altered by means of a small booster exciter generator, driven at a constant speed by an induction motor. The current from the armature of this exciter flows through the field of the booster. The desired change in the booster field is effected by altering the output of the exciter generator and reversing its polarity. This is done by strengthening, weakening, or reversing the field coils of the exciter, which is introduced into the system simply because it can deliver the relatively large current needed for exciting the booster field—this amount being much greater than it would be possible to pass through the very sensitive regulator, which can, however, easily and instantly change the small magnetic field excitation of the little exciter. The booster is in series with the battery across the 600-volt station bus bars. From the opposite ends and from the middle point of a section of 100 cells of the storage battery, three circuits are led, one of which passes through the field of the small exciter to a connection that joins together two piles of carbon disks, which are subject to the pressure of a lever. The outer end of one carbon pile is then connected to one of the wires leading to the positive pole of the 100-cell section, and the wiring from the outer end of the other carbon pile is joined up to the negative end of the 100 cells. Two circuits are thus formed, each including a separate half of the battery section and one carbon pile, while both have a common connection from the center of the battery section which passes through the field of the little exciter. The resistances of the two carbon piles when subjected to equal pressures are equal, and current will then flow from the battery through both carbon piles and back to the negative pole of the battery, there being no tendency for any of the current to flow from the central point of the two carbon resistances back to the central point of the battery or *vice versa*, through the field of the small exciter. The lever which bears upon the carbon piles is balanced upon a knife edge, and from one end of it is freely suspended the soft iron core of a solenoid, through the coil of which passes the entire output of the rotary converters. The pull of the solenoid is counterbalanced at the opposite end of the lever by a helical spring, which may be adjusted to any desired load on the machines. Slight variations of the load above and below this amount will, through the action of the suspended core of the solenoid, cause changes in pressure on the carbon piles, resulting in wide variations in the contact resistances of the carbon piles. If the carbon pile which is compressed happens to be the one whose outer end is attached to the positive pole of the battery section, the current will flow from the positive terminal of the battery through the compressed pile and the booster exciter field to the middle point of the battery, inducing polarity in one direction of the booster field to an extent corresponding to the increase of current that caused the solenoid to compress the carbon plates. When the current in the main circuit is slightly reduced, the solenoid action is reversed, pressure on that particular pile is released, and the other carbon pile, whose outer end is coupled to the negative pole of the battery section, is compressed; the current in the regulator circuit then flows from the middle point of the battery back to the booster exciter field in the opposite direction, and through the other pile to the negative pole of the 100 cells. The booster exciter field is thus reversed, which reverses the polarity of the booster field, and consequently the polarity of the booster itself, finally resulting in a reversal of battery action. The action of the regulator is somewhat analogous to that of the Wheatstone bridge.

The oil circuit-breakers for manipulating the 12,000-volt current for the feeders and for the leads to the main transformers are three-pole with two stationary contacts per pole, one for the incoming and the other for the outgoing lead of the same phase. The opening and closing gear is a simple parallel motion system, drawn up into closed position by an electrically-operated mechanism, consisting of two closed solenoids acting on magnetic plungers. When raised into contact the mechanism is held in place by a toggle joint, which locks by slipping past the center against a stop where the mechanism is held by gravity. The opening of the switch is accomplished by energizing the circuit of a second solenoid, used for this purpose only, which trips the toggle joint, with the result that the switch is instantly opened by gravity. The breaks occur near the surface of the oil instead of at the bottom of the receptacle. The oil circuit-breakers are nominally of 600 amperes carrying capacity, but can handle short circuits equivalent to a generator capacity of 33,000 kilowatts. The automatic circuit-breakers, although electrically-operated by the manual control of switches on the operating stand, are also automatically opened through relays by the current in the circuit in which the circuit-breakers are located.

The lightning arresters of the Rockaway sub-station, which are shown in one of our illustrations, are of the Westinghouse low-equivalent type, mounted upon marble panels which are carried on a steel angle-iron framework. The three arresters on the three legs of the high-tension circuit are separated by barriers of asbestos lumber. The arresters are provided with knife switches, so that they can be readily disconnected. There is a choke coil in series with each main circuit mounted near the top of the steel framework.

Railroad lines are protected by a block signal system devised to work with alternating current, by which means it becomes possible to make use of the well-known feature of short-circuiting the two rails of the track without requiring that one of them shall be devoted only to signaling purposes, which would cut

down by one-half the capacity of the track return circuit. Accordingly, a set of transformers is installed in the Woodhaven sub-station which take 11,000-volt current (single-phase) and transform it to 2,200-volt current for use in the signal system.

## TINNING.

A COATING of tin, applied to a metal, gives it, on one hand, the luster and whiteness of the tin and protects it on the other from the action of moisture, of oxygen, of hydrogen sulphide, or dilute acids. If the tin is properly applied, so that it forms a perfectly coherent and uniform layer, the metal thus coated, or tinned, shows outwardly all the chemical as well as the physical properties of tin.

The prime condition, then, of the whole process of tinning, is that there shall not be the smallest imperfect spot in the tin coating. The results of imperfect tinning may be seen in a piece of poor tin plate, which is exposed to the air. On all the places where the iron is not covered with tin, even though they may be so small as to be hardly perceptible with a magnifying glass, there will be observed in a short time rusty brown spots, constantly increasing in size. In a few weeks the oxidation of the exposed porticns of the iron will have proceeded so far that holes will be eaten through the plate, and these may be seen as little points of light, if such a piece of tin plate is held up against the light.

If two pieces of sheet iron of the same thickness, one tinned and the other untinned, are exposed to the air under the same conditions, the latter will become rusty, of course, on the surface, but the rust will not eat through it. Apparently the untinned sheet is more durable than the tinned. The fact is that on the untinned spots of the tin plate, the iron and tin, in contact with the moisture of the air, unite in producing a galvanic element, whereby the chemical activity of the oxygen of the air and the carbonic acid contained in rain water are intensified to such an extent that the iron is soon eaten through. Sheet iron which is entirely and uniformly covered with tin is as impervious to atmospheric influences as sheet tin itself.

The first and most important principle, then, in tinning—as has been already observed—is to apply the tin to the other metal in such a manner that it will form a perfectly coherent and uniform layer. Otherwise, as shown by the example given, all the labor of tinning is useless.

Besides the purely mechanical protection afforded by a coating of tin, the other metal acquires a greater power of resistance from an electro-chemical point of view. It is a well-known fact that two dissimilar metals, brought together, form a galvanic element, whereby the surfaces only are concerned, the mass of the metal not affecting the result. A piece of sheet iron or copper coated with tin becomes electro-negative through contact with the tin, and its capability to dissolve in dilute acids is thereby very considerably lessened.

### TESTING OF TIN.

Opinions vary as to whether pure tin should be exclusively used for tinning, or whether a certain admixture of lead is permissible. It is an assured fact that pure tin has a greater power of resistance, chemically considered, than tin alloyed with lead; and in cases where the greatest possible durability is essential, or in the tinning of cooking utensils, only pure tin should be employed.

A coating of tin with which lead has been mixed has not the pure white color of tin alone, but inclines to gray, and is not so lustrous. It can be produced, however, at considerably less cost and it has been found by experience that it adheres more closely than a coating of pure tin. Repeated experiments have proved with reasonable certainty, that the dull, grayish white coating produced upon sheet iron by tin heavily alloyed with lead, will protect the iron against rust for a longer time than a coating of pure tin. As the former is cheaper, quite a thick coating can be put on at slight expense, and great durability insured, with apparent fitness for all purposes except those where the poisonous properties of lead enter the question. Sheet iron intended for making cooking utensils should be covered only with pure tin; a large quantity of lead, on the other hand, may very suitably be mixed with tin for constructive purposes.

The French manufacturers of tin plate distinguish these two kinds of it. When made with pure tin, it is called "fer blanc première qualité"; if the tin is alloyed with lead (usually in the proportion of two parts of lead to one of tin, or in equal proportions), the product is sold under the name of "brilliant doux" or "terne doux" (English terne plate).

Small quantities of lead in tin used for tinning are not discoverable by the appearance of the plate, the coating having the same color as one of pure tin. To detect adulteration of tin with lead or copper, chemical means must be resorted to. Some simple methods of testing tin for its purity are given herewith. These tests can be made in a few minutes.

Dissolve a piece of the tin to be tested (a bit half as large as a pea is enough) in chemically pure hydrochloric acid, to which are added a few drops of pure nitric acid. It is absolutely essential that all the reagents used in the operation should be chemically pure, for the reason that if lead and other metals, which are liable to be contained in ordinary commercial acids, were present, entirely incorrect results might be reached.

To detect lead in this clear solution, which should not have too great an excess of acid, it is to be highly diluted with distilled water, and a few drops of sulphuric acid added; if lead is present, even in very small quantities, a milky cloudiness will appear in the liquid; a larger quantity of lead will cause a heavy white precipitate to be deposited on the bottom of the vessel. For this and similar tests, thin glass tubes, called test tubes, are used, five or six inches long and half an inch or more in diameter, closed at one end by melting up the edges; these are also used for heating liquids to the boiling point.

Another method of detecting traces of lead in tin, is to treat a sample of it with nitric acid, diluted with one-third as much water, and heat the liquid to the boiling point. The tin will be separated from the nitric acid as a heavy white powder, tin oxide. After cooling, filter the liquid off from the tin oxide, and add a crystal of potassium iodide as large as the head of a pin; if the tin contains lead, a yellow precipitate will appear, insoluble in spirits of ammonia. This test is so exact that lead can be detected in as small quantities as a ten-thousandth part of the tin.

It may be remarked here that scarcely any tin is absolutely free from lead; the presence of one or two per cent of it is usually of no consequence, since so small an amount has but a very slight effect upon the chemical properties of the tin, as regards its power of resistance to weak acids.

Iron in tin can be detected by dissolving the tin in hydrochloric acid with a few drops of nitric acid, nearly neutralizing the solution with ammonia, and adding to it a solution of potassium sulphocyanide (also called potassium rhodanide); any trace of iron will bring out a dark red color in the liquid.

Another test, somewhat less exact, is to add to the tin solution a few drops of a solution of yellow potassium ferrocyanide (blood-lye-salt); if iron is present, the liquid will be colored blue, and any considerable quantity of it will cause, after a time, a dark blue precipitate.

The best method of detecting copper is to pour red fuming nitric acid over a sample of the tin; after the evolution of brown fumes has ceased, pour the remaining liquid into a porcelain dish, and evaporate it nearly to dryness; dilute with water and mix with a quantity of ammonia. If copper is present, the liquid will take a beautiful sky blue color.

For testing tin coatings themselves for contents of foreign metals, different methods are employed. A very good one is to apply to one spot a corrosive mixture compounded as follows: Tin salt, 2 parts; water, 4 parts; nitric acid, 1 part; hydrochloric acid, 4 parts. Dissolve the tin salt in the water, and add the acids.

If the coating consists of pure tin, its crystalline structure will be shown very beautifully in a few minutes after the application of the corrosive, but if lead is present to any amount, this will not be seen.

As lead is purposely mixed with tin, so other metals are used to give certain characteristics to the coatings. In many cases these admixtures increase their beauty and durability; but when the coating is for the express purpose of covering some poisonous metal, as in the tinning of copper or brass cooking utensils, then the addition of any other metal is foolish and dangerous. Labor is expended to cover an injurious metal with a metallic mixture which itself contains poisonous elements.

### ALLOYS USED AS SUBSTITUTES FOR PURE TIN.

The metallic admixtures in tin for tin-plating are all, with the exception of iron, poisonous, and therefore only permissible in the case of tin ware not intended for use in cooking or keeping food. Besides lead, copper and iron, zinc is used, and sometimes bismuth.

An admixture of zinc or of lead makes the tin a more effectual protector of iron against rust. A French alloy, especially good for coating sheet iron for constructive purposes, consists of zinc 5.5, lead 23.5, tin 71.

If it is a question of a fine white color and high luster, 5 or 10 per cent of bismuth may be added, making a composition of tin 90 to 95, bismuth 10 to 15.

This alloy is more readily fusible than pure tin, but is more expensive on account of the high price of bismuth. Its brilliant luster adapts it especially to artistic purposes.

An admixture of one-half or at most one and one-half per cent of iron in tin greatly increases its hardness and durability. The alloy is harmless, and can therefore be used for covering kitchen utensils, but as it is much more difficult of fusion than pure tin or alloys of tin and lead, it is not easy to make a uniform layer with it.

Remarkably beautiful and durable coatings are produced from mixtures of tin, iron, and nickel; the only objection to these alloys is that they are more costly than pure tin, a fact for which, however, their great durability makes compensation. Some formulæ are here given for such alloys, compositions which have stood the test of experiment.

| | |
|---|---|
| **I.** | |
| Tin | 80 |
| Iron | 10 |
| **II.** | |
| Tin | 160 |
| Nickel | 10 |
| **III.** | |
| Tin | 90 |
| Iron | 5 |
| Nickel | 7 |
| **IV.** | |
| Tin | 160 |
| Iron | 7 |
| Nickel | 10 |

These alloys are made by melting the tin in a Hessian crucible, bringing it to white heat, and adding the iron, in the form of filings, stirring vigorously with an iron rod; finally the nickel, pulverized and heated red hot, is put in, and the mixture stirred with a hard wood stick. The decomposition of the wood by the red-hot metal causes an intimate mixture of all constituents by means of the ascending bubbles of gas. It is strongly recommended in making these or any other alloys, to stir the metallic mass for a long time with wooden sticks; this is the only way of insuring a perfectly uniform alloy of metals which have high and different specific weights. In proceeding according to the method given, the melting of the alloy under a cover of glass or borax, often recommended, is unnecessary; if the work goes on rapidly enough, no oxidation is to be feared; and the gases evolved from the wood also act as a preventive of oxidation.—Translated from the German of Friedrich Hartmann's "Das Verzinnen, Verzinken, Vernickeln," etc.

## CONTEMPORARY ELECTRICAL SCIENCE.*

PROPERTIES OF ALPHA-RAYS.—E. Rutherford defends his position against Becquerel's contention that the α-particles from radium all escape into the air with the same velocity, and that this velocity is not altered by their passage through matter. He shows that when a very narrow beam of rays is employed in a strong magnetic field, there is a distinct "dispersion" of the photographic track of the beam. The effects described by Becquerel are obscured by the scattering of the rays in air. The absence of increased deflection of the rays from a thick layer of radium after passing through aluminium, observed by Becquerel, as well as the decreasing curvature of the rays in air, are necessary consequences of the complexity of the rays. —E. Rutherford, Philosophical Magazine, January, 1906.

A NEW PHOTO-ELECTRIC EFFECT IN SELENIUM.—F. Weidert has found that one of the allotropic forms of selenium shows a well-marked photo thermo-electric effect, the thermal E. M. F. decreasing some 3 or 4 per cent, with an illumination of several hundred meter-candles. This change of the thermal E. M. F. has some connection with the resistance, which also decreases, rapidly at first, and then more slowly. But the author cannot say as yet whether the two effects are in constant proportion. The allotropic form referred to is Siemens's "second modification," and consists of a coarse-grained selenium, obtained by heating the amorphous variety to 200 deg. for 10 hours. The crystalline variety probably shows a similar effect, but the measurements are complicated by its high resistance, its inherent E. M. F., and its polarization.—F. Weidert, Annalen der Physik, No. 14, 1905.

CATHODE DISINTEGRATION.—C. Maurain has made an attempt to elucidate the process whereby a cathode is disintegrated and its substance deposited upon the walls of the vacuum tube. He finds that the particles are projected from such parts of the cathode as are exposed to canal rays or positively-charged atoms, and that they have a charge of their own, which is, however, feeble in comparison with the mass of the particles. When a plate of glass is placed inside the dark cathode space, with one edge touching the cathode and sloping away from it, the largest disintegration deposit is found on the edge furthest from the cathode, and no deposit is found to have been made near the cathode, since it was shielded from the canal rays by the plate. Magnetic fields of strength sufficient to cause a very perceptible deflection of cathode rays have no apparent influence upon the deposits, but the author has succeeded in discovering a magnetic effect by means of an electromagnet giving a field of 2,200 units. He used a cylindrical tube, and cathodes in the shape of rods 2 millimeters in diameter, in the axis of the tube. Without the field the deposit was uniform, but with the field the deposit was well marked in a plane containing the cathode and parallel to the lines of force, and another plane normal to the lines of force, but feeble in intermediate planes. The effect is best seen in bismuth.—C. Maurain, Comptes Rendus, December 26, 1905.

STANDARD OF RADIO-ACTIVITY.—In the course of some investigations on the relation between the radio-activity and the composition of radium compounds, H. N. McCoy had occasion to devise a standard of radio-activity, based upon the fact that the total activity of 1 gr. of pure uranium is 791 times that of 1 square centimeter of a layer of pure $U_3O_8$ sufficiently thick to be of maximum activity. Ordinary uranium salts are first purified by successive treatment with ammonium carbonate, ammonium sulphide, and barium salts. In converting the precipitated ammonium uranate into the oxide $U_3O_8$, it is necessary to ignite in a stream of oxygen to prevent the formation of a lower oxide. The standard film of oxide is prepared by grinding in an agate mortar 0.8 to 1.0 gr. of the substance with a little freshly-distilled chloroform until the former is reduced to an impalpable powder. This is then stirred up with about 15 cubic centimeters more of chloroform and poured into a shallow metal dish about 7 centimeters in diameter. The dish is covered until the solid is settled. The chloroform is allowed to evaporate spontaneously, and leaves the oxide in a very uniform black adherent film, each square centimeter of which gives 1/791 of the activity of 1 gr. of pure uranium. Measurements of the activity of uranium ores show an excess, probably due to radium, but possibly also due to actinium or emanium, which may be substances intermediate between uranium X and radium.—H. N. McCoy, Philosophical Magazine, January, 1906.

* Compiled by E. E. Fournier d'Albe in the Electrician.

[Concluded from SUPPLEMENT No. 1589, page 25453.]

## GAS ENGINES FOR SHIP PROPULSION.*

By J. E. THORNYCROFT.

### CANAL BARGE.

To determine the suitability of the Capitaine system for small powers, a canal barge (Fig. 7) has been fitted with a two-cylinder 35-horse-power engine, and it has been sent on an extended trip over the English canals. She left Brentford in charge of Mr. B. Dunell on January 3, fully loaded herself, and towing two ordinary canal barges, which she took to Birmingham. After giving various demonstrations there, she proceeded to Manchester, and, after making further trials there, worked her way back to the Thames at Oxford, returning to Chiswick at the end of February. The total fuel consumed on the round trip, and the various demonstration runs she made at the different places, was 5 tons 1 hundredweight, the engine having been under way for forty days.

The only difficulties experienced on the trip were due to the shallowness and the bad state of many of the canals; the water inlets on several occasions becoming choked with mud, and the propeller, which was of the reversing pattern, damaged by coming into contact with different sorts of rubbish, which had been allowed to accumulate in the canal bed. It would appear that the only sort of propeller suitable for canal work is one of the strongest description, made of steel, which can be relied upon to bring up the engine, if necessary, without damage to itself when striking large stones, or getting jammed up with old ropes. The particular barge to which this machinery was fitted was originally built to be propelled by steam, and it is interesting to note that a considerable gain has been effected in cargo space by the substitution of the gas plant. In addition to the high economy which can be obtained with the gas plant for canal barge propulsion, there is the great advantage over the oil of absence of any smell—an objection which the barge owners state prevents the adoption of the oil motor for their work, as the cargo they frequently carry would be damaged by taking up the smell of the oil.

It has been suggested that the exhaust from the engine would be dangerous in passing through canal tunnels. No difficulty from this source was experienced, and, indeed, it is difficult to see why there should be any more danger than from the carbonic acid gas given off by the boiler of a steam barge.

To demonstrate the possibility of using gas plants for large powers, Messrs. William Beardmore & Co., who are joint owners with the author's firm of the British Capitaine patents, are constructing sets of engines of 500 and 1,000 horse-power, to run at a speed of about 130 revolutions per minute. The 500-horse-power set is generally of similar construction to the smaller sizes, the framing consisting entirely of steel plates arranged to transmit the stresses directly from the crank shaft bearings to the cylinder heads. Cam shafts for operating the inlet and exhaust valves are placed on either side of the cylinders, the valves being operated by rocking levers, so that, when the cylinder head is removed, free access can be obtained to withdraw the pistons. The 500-horse-power engine consists of five cylinders, each capable of developing 100 horse-power. The reason for adopting this size of unit has been that the largest piston is being employed which it is thought safe to use without water-jacketing it. The 1,000-horse-power engine has the same diameter and stroke of cylinder, but the engine is double acting, and the pistons are necessarily water-cooled. These large engines are started by admitting compressed air or gas through special starting valves, and reversing is effected by an arrangement for shifting the cams for operating the valves to the right relative position for running the engine in the opposite direction. Compressed air or gas is admitted to make the engine give the first few revolutions in the required direction, the engine being uncoupled from the propeller shaft by means of hydraulic clutch or coupling for the short time while reversing is taking place.

Two systems of ignition are fitted, one of the low-tension magneto type, and the other of the high-tension Lodge system. The cylinders and the various bearings are lubricated by a system of forced lubrication, a distributor giving a full pressure of oil to each bearing in turn.

The producers for these engines are arranged to work with bituminous fuel, the producer being stoked from the top, and the gas drawn off from the hottest zone of the producer. The green fuel on the top is pre-heated by the hot coal underneath, and the tarry products carried through the incandescent fuel. A special feature of the producer is the arrangement for preventing the caking of the fuel and the formation of cavities, which are so difficult to avoid when bituminous fuel is employed.

As some of the most important parts of the new producers are not yet fully protected, further details cannot at present be published.

In the first experimental vessels to be fitted with these large engines, the usual "donkey" boiler will be retained for the purpose of working the steering and other auxiliary engines, and for working the compressors for starting up the engines, when the plant has been some time at rest. When under way, these boilers may be heated by the gas from the producer.

Fig. 8 shows the machinery space of the 7,000-ton cargo steamer recently constructed by Messrs. Beardmore & Co., Ltd., and an alternative arrangement which has been got out by Mr. W. W. May (Messrs. Beardmore & Co.'s engineer) to fit vessels of the same power with gas engines and producers. With this arrangement a saving of 13,000 cubic feet of cargo space is effected, besides a considerable gain in weight. It will be seen that the producers themselves are so small that they can be placed partially above the engines.

It has been suggested that trouble would occur from the poisonous gases from the producer in the confined spaces on board ship, but, if proper ventilating arrangements are made, there should be no trouble from this cause; indeed, the crew of the gas barge already referred to frequently slept in the producer-room during the trial, which was conducted in very cold weather. Although this course is not to be recommended, it indicates that there need be no danger.

There are many instances of gas engines running for stationary purposes for long periods on town gas without a stop of any sort.

With a view of ascertaining what results may be

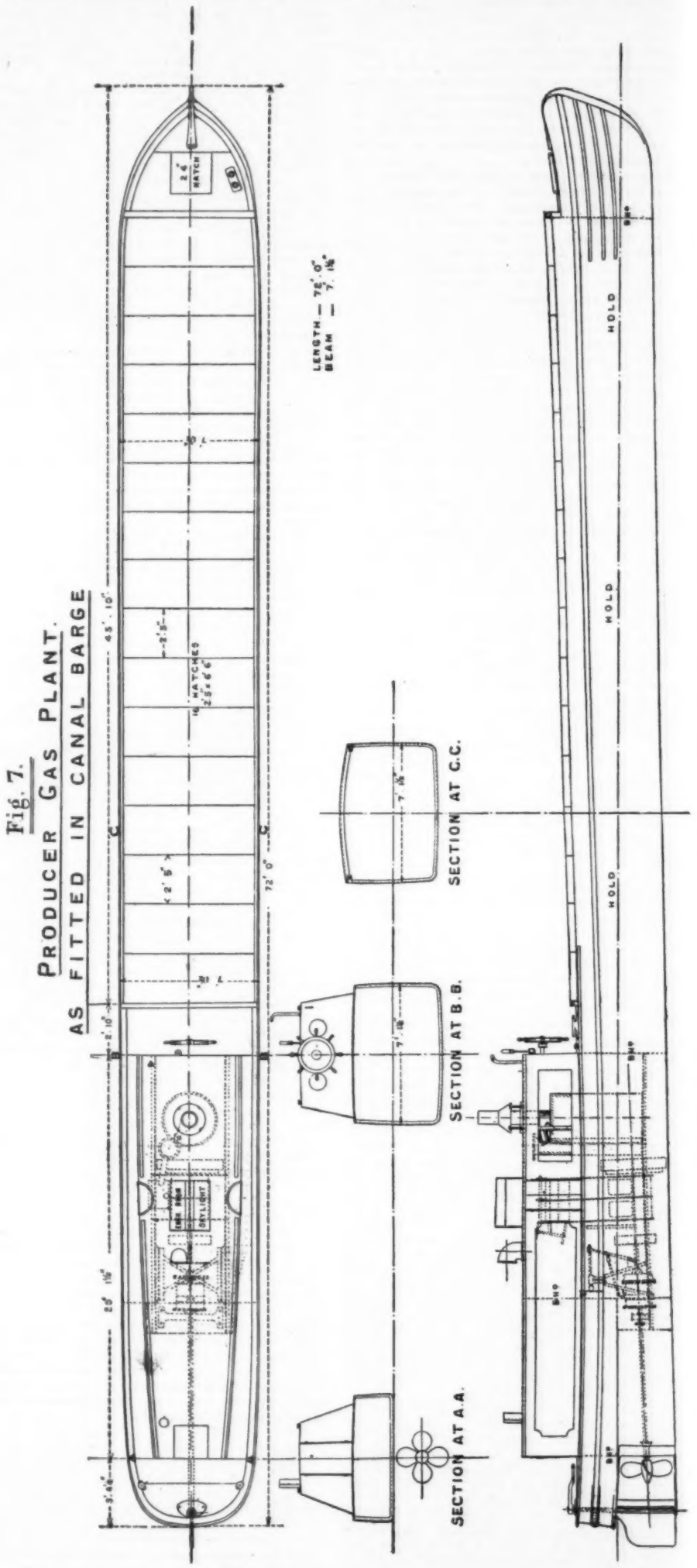



Fig. 7. PRODUCER GAS PLANT. AS FITTED IN CANAL BARGE

* Read before Institution of Naval Architects.

expected with producer gas, inquiries have been made of a number of large gas engine manufacturers, and it appears that there are many engines of 250 to 400 horse-power per cylinder running regularly every week from Monday morning to Saturday afternoon without a stop. The Premier Gas Engine Company give an instance of an engine which has made a run of fifty-one days without a stop, the previous run being forty-nine days without a stop of any kind.

From the various physical changes which take place within the cylinder of an internal combustion engine, it is evident that it cannot well compete with the steam engine as far as continuous running without cleaning and adjustments is concerned; but, from results that are being obtained in everyday use, it is submitted that the reliability is now so good there need be no hesitation in adopting them on this account.

SPACE REQUIRED FOR 2,000 H.P. GAS ENGINES & PRODUCERS.

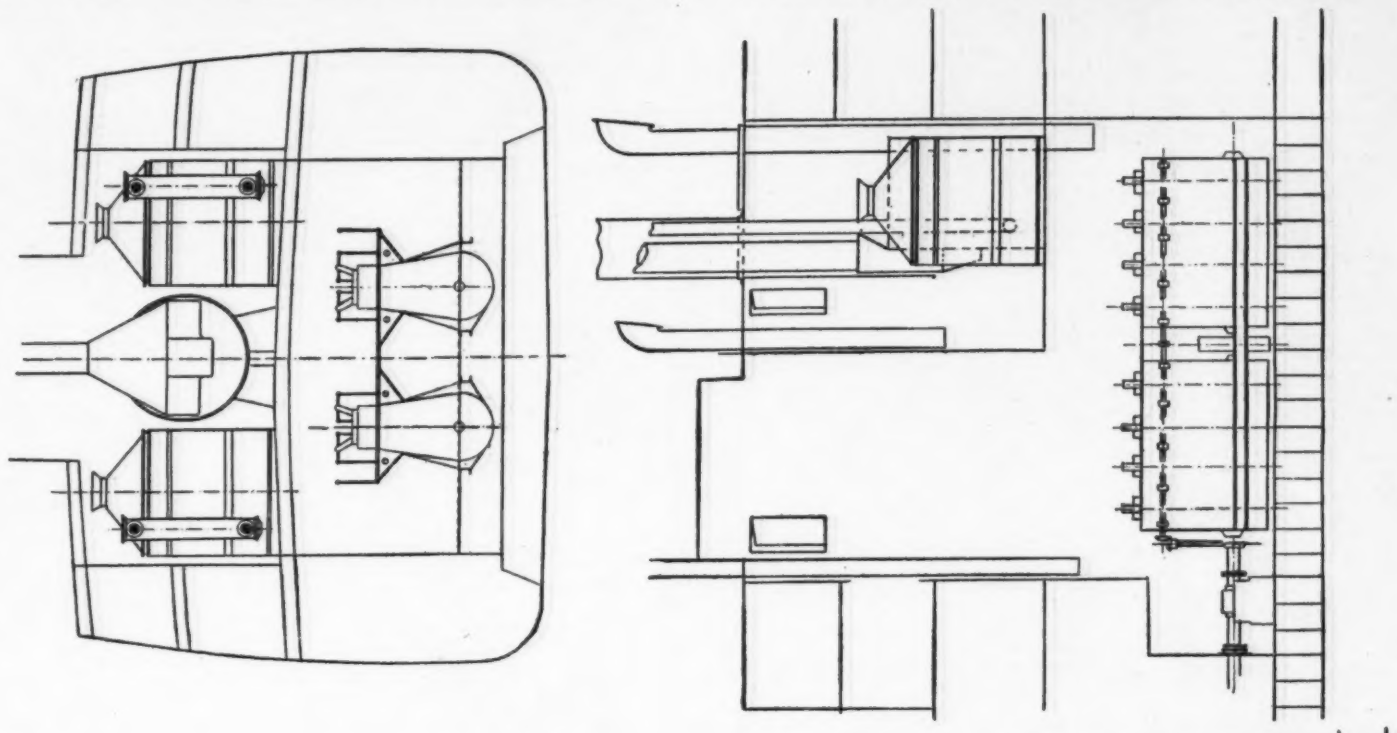


Fig. 8.

SPACE REQUIRED FOR 2,000 H.P. MARINE ENGINE & BOILERS.

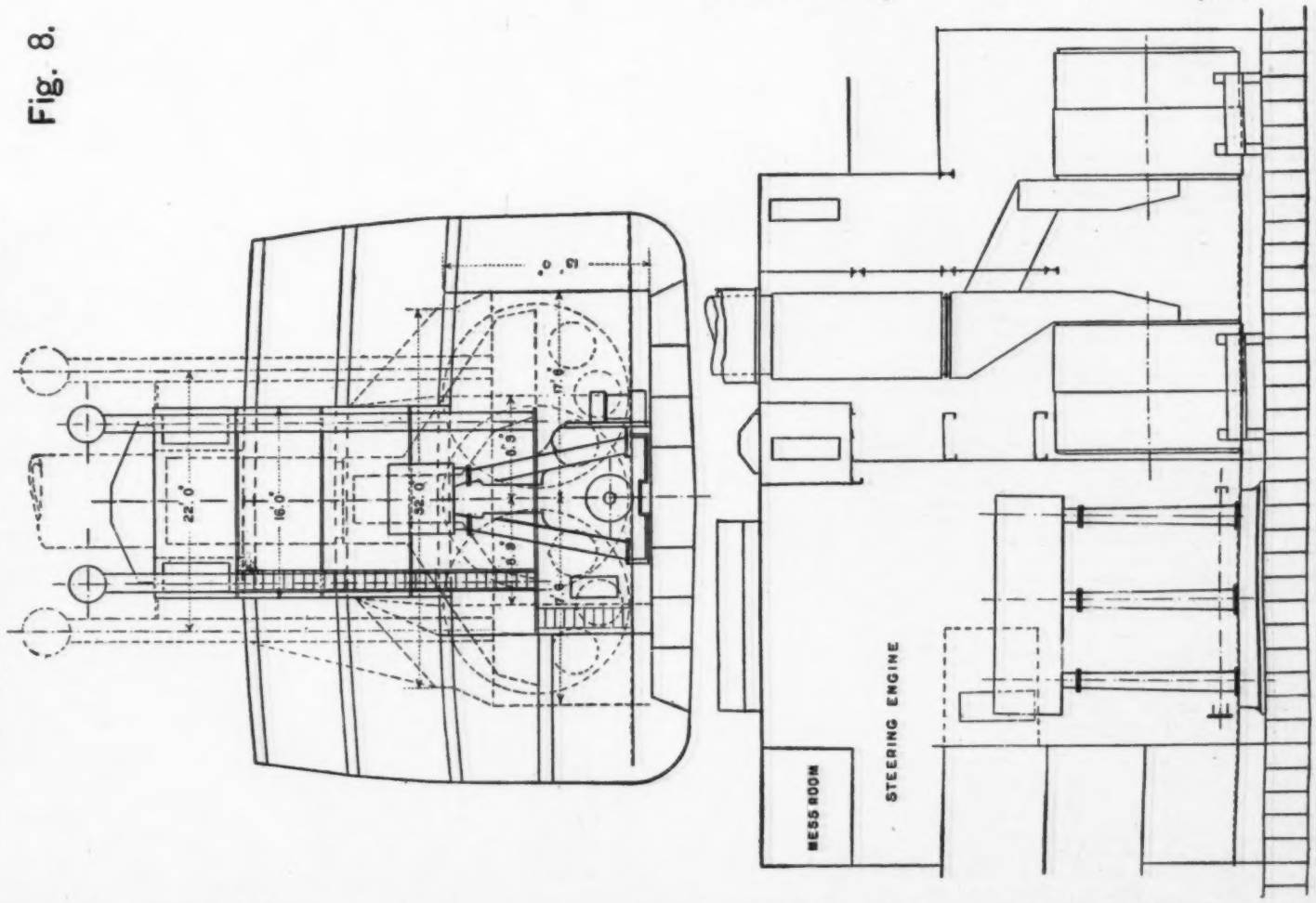



Fig. 8.

[Continued from SUPPLEMENT No. 1589, page 25454.]

## CANALS: ANCIENT AND MODERN.—II.*

FRANCE early exercised her ingenuity and activity in the construction of canals for inland navigation. The canal of Briares was begun under Henry IV., and finished in the reign of Louis XIII. It opens a communication between the Loire and the Seine, and then between Paris and the western provinces. Commencing at the Loire near Briares, it passes to Montargis, joins the canal of Orleans, which was begun in 1675, and falls into the Seine near Fontainebleau.

The canal of Picardy connects the River Somme with the Oise. The most considerable work of this kind is the canal of Languedoc, called the canal of the two seas, which forms a junction between the ocean and the Mediterranean. It was first projected under Francis I., but began in 1666, and finished in 1681, under Louis XIV., during the ministry of Colbert, and by the skill of Riquet, the engineer. It established a ready communication between the two fertile provinces of Guienne and Languedoc, and extends from Cattees, in the Bay of Languedoc, to the Garonne. In some places it is conveyed by aqueducts over bridges, under which other rivers pursue their course. Near the town of Beziers it was conveyed under a mountain by a tunnel—then thought extraordinary—720 feet in length, and lined with freestone. Its breadth is 144 feet, including towing paths, its depth 6 feet, and its length about 180 miles. The expense of its construction was about $2,270,000, defrayed partly by the king and partly by the province of Languedoc.

On the reduction of the army and navy in 1782, after the conclusion of the American war, the disbanded soldiers and sailors were employed in the construction of three navigable canals—viz., one called the Canal of Dehune, extending from Chalon-sur-Saône to the town of Dijon, on the Loire, through an interval of 60 miles, and forming a junction with the Saône and the Rhone; a second, called the Canal of Burgundy, reaching from St. Jean-de-l'Aune to the village of Roch through a space of 150 miles, and opening a communication between the Saône, the Rhine, the Yonne, and the Seine; and a third, called the Canal of Neuf-Brissac, which commences at the village of St. Symphoriex on the Saône, and passing the city of Besançon, is continued below Strasburg, forming a junction of the Saône with the Rhone, and of the Ill with the Rhine.

British Canals.—That the navigation of British rivers by ships or smaller vessels has long been an object of considerable importance, will appear from Magna Charta, which has made a special provision in the twenty-third chapter for the putting down of weirs and other obstructions in the rivers of England; and from the Statute 25 Edw. III., c. 4, which sets forth, that "whereas the common passages of boats and ships in the great rivers of England be oftentimes annoyed by inhansing gores, weres, stages, etc., in great damage of the people: it is established, the same shall be cut and utterly pulled down, without being renewed, and that writs be sent to the sheriff to do execution."

After two other unsuccessful attempts by statutes in

* London Engineer.

the succeeding reigns to prevent the free navigation of the rivers from being obstructed by individuals intent upon fishing, embanking land, or building mills, bridges, or making fords, the Statute 4 Henry I., c. 12, appointed special commissioners for carrying the above statutes into effect, whose powers were continued and enforced by two other acts, prior to the 23d Henry VIII., c. 5, which being entitled, "The Bill of Sewers with a proviso," appointed a general commission of sewers, with large powers that are still in force and acted upon, for making laws and ordinances, and compelling obedience thereto, for the "removing and preventing of impediments and annoyances on rivers, streams, and floods, whereby the passage of ships and boats might be letted or interrupted." And by the statute of Edward VI., c. 8, the last-mentioned and former statutes were confirmed and made perpetual. During the above period several other statutes were also made for removing obstructions in particular rivers.

The general laws of the land proving so very ineffectual for protecting internal navigation from the encroachments of individuals and the effects of neglect, this probably suggested the propriety of those particular grants or statutes which we find enabling corporations, and in some instances individuals, to take particular rivers under their charge, and to receive tolls or dues from the vessels navigating within their particular district.

In process of time, as population increased and the advantage of water carriage became more apparent, further grants and acts of Parliament were made, authorizing companies or individuals to extend the navigation on certain rivers into the country, generally to reach some city or great town; these acts generally enable the parties to deepen, and in some instances to straighten the course of their rivers, to embank them where too wide, to erect jetties and sluices, and, in later times, to erect pound-locks, for gaining the ascent to the different mill dams upon the river. But the constant tendency of rivers, especially rapid ones, to cast up banks of sand or gravel in particular places, their deficiency of water in times of drought, and superabundance in times of flood; the ravaging effects of these last in destroying the works erected for the use of the navigation, the great labor and difficulty of towing or dragging vessels against the stream, especially where there was not a towing path for horses near to the channel of the river, and yet not subject to be overflowed and rendered useless in times of flood; the very lengthened course of most rivers, arising from their serpentine, and in some instances varying, channel, were not also among the smallest of the difficulties attending them; these at length suggested the propriety of leaving the bed of the rivers in some instances for a new cut for the navigation across a neck of land, with a pound-lock at its lower extremity.

As these side cuts and pound-locks were increased in number, to shorten the course of the rivers, their superior advantages became so apparent that a company of gentlemen and merchants, who had in 1755 obtained an act of Parliament authorizing them to make Sankey Brook navigable from the Mersey River to near St. Helens in Lancashire with the powers at that time usual in navigation acts, for the purchasing of land and other things necessary for the intended navigation at a fair estimate to be made by commissioners named in the acts, determined, after mature deliberation, to avoid the bed or channel of the brook altogether, and to make one entire new cut or canal as near as convenient to the bed of the river, with locks thereon, in such places as the falls of the ground should render necessary; and this canal they accordingly made about 1760.

Thus navigable canals had their rise in England; but a less fortunate set of men, under the power of an act obtained in the year 1730 for making the River Stroudwater navigable from the River Severn to near the town of Stroud, although the act empowered them "to make as many new cuts as they may judge proper, and of what length and breadth as they shall deem convenient"; when they had, about the year 1774, determined upon following the example of the Sankey proprietors, and in imitation of the Duke of Bridgewater's and several other canals which had then been executed or were begun, by cutting a canal on the side of the Stroudwater River, they were stopped by an expensive lawsuit, carried on by certain mill and landowners in the neighborhood, whereby the distinction between the river navigation acts and canal acts was established by the court of exchequer, before which the case came to be argued.

Some idea of the state of communication in England before the era of canals may be gathered from the third chapter of Macaulay's history. The markets were often inaccessible during several months. It is said that the fruits of the earth were allowed to rot in one place, while in another place, distant only a few miles, the supply fell far short of the demand. When the canal system was being fairly started in England, only one stage coach ran between London and Edinburgh, starting once a month from each city, and taking ten days for the journey in summer and twelve days in winter. It took fourteen days to travel between London and Glasgow. In 1760 it took three days to travel from Sheffield to London, and in 1774 Burke traveled from London to Bath with what was described as "incredible speed" in twenty-four hours.

Much of the discomfort, the high range of prices, the general existence of poverty, the limited extent of commercial operations in the early part of the eighteenth century, were, no doubt, due to the imperfect development of the modern processes of manufacture and distribution. But the high cost of transport had also much to answer for. With only the old pack-horse facilities, it would have cost an almost incredible sum to have performed the same service which the railways now render to the people of England in the transport of minerals and merchandise.

The introduction and development of internal waterways gave remarkable stimulus to commercial and industrial progress. It enabled raw materials to be transported at about one-tenth of what they had formerly cost, and facilitated the interchange of commodities between the different parts of the kingdom to an extent previously unknown. Up to the period of the first canal acts, English waterways were under the control of the state, or of authorities appointed by the state for the conservancy of navigation.

With the construction of the first canal began the era of private enterprise in respect of inland navigation, which owes its existence to the genius of Brindley, and to the unflagging determination of the Duke of Bridgewater, whose efforts in the cause of progress were, like those of Stephenson, and the pioneers of railway enterprise after them, at first strenuously opposed by the public, and almost entirely neglected by the state. The turning point of public opinion, as regards both canals and railways, was the discovery that money might be made out of them. Brindley's grand project of uniting the four great ports of Liverpool, Hull, Bristol, and London by a system of main waterways, from which subsidiary branches might be carried to contiguous towns, had been to a large extent successfully accomplished at the end of the first quarter of the nineteenth century, and when canals began to pay dividends the nation began to admit their public utility.

---

[Concluded from SUPPLEMENT No. 1589, page 25463.]

## THE METALS IN HUMAN PROGRESS.*

By NELSON P. HULST.

TIN ore is one of the least profusely distributed of the metalliferous minerals. In the then known portions of the eastern hemisphere it occurred at Zinnwald in Germany and at Cornwall in England. Copper ores, and gold in stream beds and in lodes, were far more universally distributed. Tin, and tin only, would suffice for the production of the bronze of early times. The known world was scoured by the ancients, we are led to believe, in order to secure these coveted metals. Hence navigation and commerce were greatly stimulated and extended in the quest for tin and copper. New and unknown lands were invaded by the seekers of these metals. The Phœnician merchants with their trading ships made Tyre the mistress of the commerce of her time. Her adventurous navigators knew intimately every indentation of the Mediterranean, and all the navigable streams which flowed into it. Their craft plowed the Red Sea, and continued on along the coast of Africa until they had circumnavigated it long before the beginning of the Christian era. They coasted north from the Straits of Gibraltar, even to the British Isles, where at Cornwall they found their most plentiful source of tin. Wherever there were accessible mining districts, these daring, these resourceful Phœnicians founded colonies. Their most notable colonies, established for mining, were at Cornwall and on the Iberian Peninsula, the Kingdom of Spain, we call it, which in Biblical times bore the name of Tarshish. Here in Tarshish mines of fabulous wealth in silver were discovered. Secular history tells us of the hosts of miners, thousands upon thousands, who swarmed throughout this land of riches. Thence the Tyrian ships went home deep laden with their precious treasures. Even their anchors at times were made of silver, that they might thus transport the largest possible cargo of it. The advance of Tyre to great wealth and power is considered to have been due to riches poured into her coffers by these mines of Tarshish, and by what was obtained from her numerous mining colonies elsewhere. In order to secure supplies of copper in early times, the Egyptian ruler Senoferu of the third dynasty planted military colonies on the Arabian peninsula to protect his subjects who were engaged there in mining copper. At a subsequent time Rameses the Great accomplished the construction of the first Suez Canal, in order that Egypt might have direct water communication with the Arabian copper mines. At a later time Roman soldiers went overland from Rome and crossed the English Channel to Cornwall, that they might secure for themselves its tin mines—which would make them independent of the Phœnicians, who for so long had held control of the production of tin.

The search for metals during the Bronze Age brought wealth to the cities of Egypt and to the cities of the Mediterranean basin generally. Throughout the period from 1000 B. C. to the early portion of the Christian era, when Tyre, Nineveh, Babylon, Carthage, and Memphis flourished, when Athens was at the zenith of her brilliancy in art and letters, and during the period when Rome was expanding to become the master power of the world, the splendor of these several cities in architectural grandeur, the wealth of the monarchs in precious metals, wrought and unwrought, the stores of bronze creations of art, decorating lavishly palaces and temples, seem to this modern age of culture almost fabulous. Diodorus mentions that within this period the annual product of the mines, tributary to Egypt, was over six hundred million dollars. It was not converted into coined money, a process not then invented, but weighed out in bars and ingots. So plentiful was gold in Ethiopia, that one of the kings of this realm bound his prisoners with burdensome chains of gold, this metal being more common there than bronze. Copper was wrought into ornaments for the Ethiopians, who preferred it to gold. The poems of Homer abound in references to the profusion of jewelry and ornaments in use in the times he writes about. The magnificent discoveries by archeologists in the ruins of the cities of Mycenæ and Camirus on the plains of Troy fully bear out Homer's tales of them. In their metal work, as in their architecture, the ancients, in the brilliant period mentioned, vied with each other in the creation of colossal productions. Such was the brazen laver of Solomon's temple, the Colossus of Rhodes, the great golden cows which Cræsus with other gifts donated to the temple at Ephesus. Every monarch seemed impelled to excel his contemporaries as well as his predecessor in some application of the metals. Phalerus, King of Agrigentum, not to be outdone in such rivalry, had a brazen bull cast by Prillus of Athens. Its size was sufficient to receive two men in its hollow body. Prillus designed the interior mechanism of this brazen bull so skillfully that the groans of victims imprisoned within, stimulated by a fire beneath it, resembled the roaring of the living animal. Poor Prillus must have repented himself that he ever undertook such a contract, since he was the first victim who proved the perfection of its vocal mechanism. The historical accounts given us of Babylon, as to its lofty walls and metal furnishings of temples, almost overwhelm one with astonishment. The walls of the city towered to a height exceeding three hundred feet. They were pierced with a hundred openings, framed with bronze, from which swung gates of bronze, some of which were so large and ponderous that machinery was required to open and close them. Within the walls a temple dedicated to Bel contained a golden statue of this god forty feet high, besides other golden statues, a table forty feet long and fifteen feet wide, and other colossal furnishings of the same metal. Outside and below the temple were shrines and altars and other furnishings, refulgent with golden statues.

Tyre also had a temple profusely adorned with golden objects. It was Solomon's ambition to have the temple of Jerusalem surpass the Tyrian's splendor and magnificence. These three places of worship were but a few of those of which history makes mention. All of them were rich in barbaric gorgeousness of metallic statues, furniture, and ornaments of the precious metals. This ostentatious show of wealth, which one and another of the ancient cities delighted to make, served also to arouse the cupidity of ambitious monarchs. Victorious armies marched against them. The temples and palaces were despoiled, and the vast treasures of precious metals and ornaments and furnishings of bronze fell into the possession of the conquerors. History informs us that Alexander the Great had so enriched himself with spoils by his conquests, that at a banquet which he gave to his six thousand captains, he seated each one of them upon a silver chair or couch.

As before stated, it was about 500 B. C. when, with the more highly civilized people, bronze ceased to be the dominant metal for tools and weapons, and iron came into general use for the manufacture of these implements. Iron had been known for a considerable portion of the Bronze Age, and among some peoples had a limited use. The Vedic poets mention it as in possession of their prehistoric ancestors, whose artisans had acquired skill in fabricating it into tools. The earliest of these poems were written, according to the philologist Whitney, more than four thousand years ago, before the several streams of the earlier migrating Aryans had flowed westerly and northwesterly into Europe, as well as into the plains and river valleys of India, into Persia, and along the southern shore of the Mediterranean Sea. Undoubtedly these Aryan emigrants carried with them their knowledge of producing iron from its ores, for the quarrying and dressing of the intractable syenitic granite into the huge blocks composing the pyramids could only have been accomplished with tools of steel—which is essentially an iron product modified by a little carbon and by skillful heat treatment. The Etruscans in Northern Italy were of Aryan stock, and they at a period long prior to the beginning of the Christian era possessed the art of smelting iron from its ores, some of which came from the mines of Elba. If one is disposed to wonder why iron came so slowly into general use after mankind had learned, even before the dawn of history had begun, that it was superior in some respects to bronze, it is sufficient to state that bronze did not require so much skill in its production. Although iron had many useful properties, it was not so malleable as bronze, and was probably more costly to produce, while it was not always as uniform in its qualities.

The workers of iron in very early times could not melt it, since it required a very high degree of heat, which we are sure was beyond their attainment. It could not take the place of bronze, for such iron as they produced, what we know as wrought iron, would not serve for cutting tools and weapons. The knowledge and skill requisite in the treatment and manipulation of wrought iron to convert it into steel were undoubtedly possessed by a few artisans before the building of the pyramids, but these skilled workers evidently guarded their secret carefully, as has been the habit of all steel producers from their day to this.

Prior to the close of the Bronze Age the knowledge of producing steel economically and forging it into tools and implements of war had become sufficiently general. Iron ores were so much more abundant than

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

the ores of copper and tin, that the production of iron was capable of greater expansion. These facts caused iron to become the more important metal about 500 B. C., which is accounted the beginning of the Iron Age. It was the custom of those times for the victor to hold the vanquished in slavery. Thus, by the fortunes of war, all captured artisans were transferred to a new allegiance. The skilled iron workers of Etruria were absorbed by Rome from time to time as defeat came to the Etruscans. With the downfall of the Roman empire all metal production languished. Later in the dark ages, iron manufacture became especially developed in Spain. Her workers in that period surpassed all others in the fabrication of steel. Toledo blades, the product of her artisans, were drawn in many a historic battle. Their fame spread so far afield, that many of these remarkable Spanish craftsmen were drawn away to France and Germany. They introduced their peculiar Catalan forges in these countries, which with successive modifications have been evolved into the modern iron-smelting furnaces. Up to the time of the evolution of the Catalan forge into the larger iron-smelting furnace, the iron worker had produced wrought iron or a steely iron directly from the crude ore. This was a slow and wasteful as well as a costly process. The later large smelting furnaces yielded at far less cost, and with practically no waste, an iron product unlike that of the forge in that it could be melted by a moderate degree of heat. This variety of iron, dissimilar to wrought iron or steel, could neither be forged nor tempered. It was most suitable for all kinds of castings requiring moderate strength. It was especially serviceable for the steam-engine cylinder, and it has contributed very much to the success of this machine, which in the brief period since Watt's time (1769) has affected so powerfully the interests of mankind.

An English inventor, Cort, but little more than a hundred years ago, devised a method whereby cast iron could be converted into wrought iron, at a far less cost than had been possible with the Catalan forge. This new indirect method of obtaining wrought iron gave a great impetus to iron manufacture in England. She had already at the beginning of the nineteenth century taken the leading place among the nations in the production of iron, attaining the volume then of one hundred thousand tons per annum. Her manufactures grew apace, and with them her wealth and commercial power. Following Cort's invention came that of the steam locomotive, and the metal track for its use. Later the invention of Bessemer gave to the world a method of producing steel from cast iron in a much briefer time and at far less cost than had ever before been accomplished. In but little more than a third of a century the steel production of the world has grown to astounding proportions. Steel has now quite supplanted wrought iron for all commercial uses.

If the archeologists have warrant in dividing the period man has dwelt upon the earth into the three ages, stone, bronze and iron, because these materials were successively dominant factors of influence in his affairs, then it is allowable to assert that mankind has already entered upon the age of steel. Steel contributes largely to man's means for accomplishing his titanic plans. It is covering all civilized lands with railways as a network. Along its wires his thoughts are repeated to the ends of the earth. Railway engines and great ships of steel speed across space with a swiftness that would have tired Mercury with his winged sandals. The successive ages of stone, of bronze, of iron, and of steel cover the whole period of man's abode on the earth. That the metals have been of inestimable import in elevating the human race is as recognizable as that they have been all-important in contributing to his creature comforts.

Let us glance at a very few of the applications of the metals, or the study of metals, which have tended to uplift man, to lead him to a higher, nobler plane of existence. We have seen that in the Stone Age the cave dweller possessed the artistic sense which found expression in the rude semblance of a reindeer that he carved from an antler of this animal with some sharp stone for a tool. Again his artistic impulse was gratified by tracing or etching in outline on an elephant's tusk a fair picture of this animal. But the cave man was sadly handicapped in any artistic ambition he may have had to cultivate his artistic sense. His inefficient tools were against him. His struggle for the bare means of a sorry existence, and the needed, constant watchfulness on his part to defend himself, or to escape, from the ferocious beasts ever surrounding him, must have left him little leisure.

The rare excellence of the art of Phidias and of Praxiteles could never have been expressed in imperishable marble, nor could the beautiful creations in architecture which have made the brilliant age of Greece the glory of mankind, have been wrought, had not man compassed the use of metal tools. This, too, was the most illustrious age of letters. How much of inspiration to noble achievement, how much of stimulation to mental growth, the art of this time, displayed in marble statues and architectural structures, which owed their very excellence to tools of metal, begot in citizens of Greece, can never be estimated. The art of the artists and the genius of the scholars of this time must have acted and reacted on each other, to elevate and ennoble. Surely the sculptor's metal tools of Phidias's time must be reckoned as having had no mean share in the uplifting influence which his art exerted then, and which has come down to all the ages as an inspiration to lofty ideals.

Alchemy was the natural child of metallurgy. Its devotees aimed to discover the essence of metals. They were the most eminent natural philosophers in Spain, when about the sixth century that kingdom was the intellectual center of the world. They were inspired with the hope of transmuting the base metals into precious metal. Of necessity it was carried on in seclusion, since those who hoped to discover nature's secret feared lest envious eyes might anticipate and outspeed them on the road to fame and fortune. Hence it was called the black art. Whether their purpose was ignoble or not, their efforts became the seed of a science which grew and blossomed later into chemistry. The students of this nobler science have enriched humanity with the means of alleviating human suffering, have discovered the source of pestilential ills and swept them away with beneficent antitoxin preparations. Had there been no discovery or no use of metals, the alchemists, the chemists, the blessed anesthetics, would probably never have been known.

One of the applications of iron, or rather steel, which has been of the greatest and most far-reaching consequence to our race is its use in the mariner's compass. The earliest navigators, before the compass was used, dared only to skirt the shores of the seas they sailed. In proper weather they might venture a little distance out of sight of land, having the sun or the pole star to guide them. Storms were their greatest dread. Having the compass to direct him, Columbus sailed westward, confidently hoping to reach Asia. He failed of his purpose, but he gave to mankind a far greater gift by discovering the western hemisphere, a new world. How much commerce has been benefited by the mariner's compass it would take volumes to relate. The new world has become the granary of the old. It has become the asylum, too, for lovers of freedom. Far greater than the material benefits which the mariner's compass has conferred on humanity, has been its service in discovering this new world, for the home of a new nation, founded on representative government. It has become the shrine of freedom to the monarch-ridden peoples of Europe. Growing amazingly in population, culture, wealth, and strength, it has breathed a silent influence over all European monarchies. The establishment of the republic of France was made easier and brought to accomplishment sooner by their people having been shown the way by our nation. The existence of our free land has tended to ameliorate the harsh rule of monarchs in other European countries. It has freed Cuba from the cruel yoke of Spain, released Mexico from an alien monarch, and stands guard to assure the weak states of Central and South America security from foreign rule. Had there been no compass invented, by which Columbus guided his ship to the new world, most probably there would have been no colonies in America, and a great republic in Europe might never have come into existence.

I need only mention printing with metal type as a use of metal, which has been of transcendent influence in the intellectual and moral growth of man. One could go on indefinitely in the enumeration of the uses of metals which have affected the higher part of man's nature, but I must stop somewhere. We have been looking across time in a most hurried glance, and we have observed man in two widely different conditions. Far in the perspective, in his savage state, we have seen him, when even at his best, possessed of no better tools than polished stone would make. His arts were few, his intellectual faculties scarce awake, his moral nature at a low ebb. It is the infancy of the human race. He is there like the human child, which in its earliest years learns of the things at hand by the exercise of its five senses. Its mental development is slow, and its moral perception awakens only after the intellectual faculties are more or less developed. If some of the mental faculties are wanting in the child, or are notably defective, then there can be only slight moral development or none at all. If the child has but a limited number of things with which to sharpen its intellect, the mental growth will be to a certain degree arrested, and thus the moral growth will be retarded. Following man down through the ages, we see him advancing in intellectual strength and moral purpose. All along in his history since he first knew the use of metals, he has, through the increasing applications of them, been improving his physical condition. Coincident with such improvement have come increased leisure and opportunity to cultivate the intellectual faculties, and upon the growth of these has followed the development of his moral sense. The use and study of the metals have contributed to his mental development, and, therefore, have potentially aided in his moral advancement.

## FOREIGN COMMERCE OF UNITED STATES.

THE foreign commerce of the United States during the fiscal year which ends with this month promises to exceed in both imports and exports that of any earlier year. The details of 10 months of the year's commerce have been announced by the Department of Commerce and Labor through its Bureau of Statistics, and should May and June show as large a monthly average as that of the 10 months for which the record has been made, the imports will be 1,225 million dollars, and the exports 1,786 millions, or a total of a little more than three billion dollars. Whether the two months for which the record has not yet been received will show as large an average as that made during the ten months is quite uncertain, as May and June figures are usually slightly below the average, both as to imports and exports; but it seems quite apparent that both imports and exports will be larger than in any preceding year.

The figures of the fiscal year 1905 exceed, both as to imports and exports, those of any prior year, and the fact that the recorded imports of ten months of 1906 exceed by nearly 100 millions those of the corresponding months of last year, and that exports exceed by over 200 millions those of the corresponding months of last year, suggests that there can be no doubt that the fiscal year 1906 will make the highest record ever shown in both imports and exports, and therefore the largest total of foreign commerce.

The remarkable growth of about 100 million dollars in imports and 200 millions in exports presents some interesting facts. In imports the increase occurs in all classes except foodstuffs, and in exports the increase occurs in every class, but especially in foodstuffs and manufactures. In the class of imports designated "articles in a crude condition for use in manufacturing," the increase in the ten months ending with April amounts to 25 million dollars, a gain of about eight per cent over the corresponding months of last year. The articles wholly or partially manufactured for use in manufacturing show also an increase of 25 millions, a gain of about 21 per cent. The group "articles manufactured ready for consumption" shows an increase of 35 million dollars, a gain of nearly 25 per cent. The group "articles of voluntary use and luxuries, etc.," shows an increase of 23 million dollars, a gain of about 19 per cent, while "articles of food and live animals" show a reduction of 22 millions, a loss of about 9 per cent.

The decrease in the importation of articles of food occurs chiefly in sugar and coffee. The value of the sugar imported in the 10 months ending with April fell off about 12 million dollars, being 70 million dollars, against 82 millions in the same months of last year. This fall, however, is due wholly to a reduction in the price, the quantity of sugar imported having actually increased about 50 million pounds as compared with the same months of last year. Coffee shows a fall of about 13 million dollars, the figures for 10 months being 64 millions, against 77 million dollars in the same months of last year; the reduction occurs in quantity as well as value, the quantity of coffee imported for the 10 months being about 743 million pounds, against 954 million pounds in the same months of last year. Tea imports also show a slight reduction, being 13½ million dollars in value in 10 months of 1906, against 15 1/3 millions in the same months of last year; the reduction occurring in quantity as well as value.

The increase in the value of articles imported for use in manufacture occurs in several great classes. Chemicals, largely used in manufacturing, show a gain aggregating about 7 million dollars, raw cotton a gain of about 11½ millions, hides and skins a gain of about 15 millions, tin a gain of about 5 millions, tobacco a gain of about 4 millions, copper an increase of about 4½ millions. This indicates an increase of about 37 million dollars, while the total increase in all articles of this class was but about 25 millions, due to the fact that raw silk shows a reduction of about 4 million dollars, wool a reduction of about 2½ millions, and India rubber a reduction of about 5½ million dollars. In the articles partially manufactured for use in manufacturing, and in manufactures and luxuries, growth occurs in a large number of classes. Iron and steel increased about 5 millions, manufactures of fibers about 9 millions, manufactures of cotton about 11½ millions, and manufactures of wool about 5 millions. Imports of diamonds and other precious stones also continue to show a large increase, the total for the 10 months ending with April being about 33 million dollars against about 27 millions in the same months of last year.

The exports show increases in every group, agricultural products showing a gain of 150 million dollars compared with the same months of last year, and manufactures an increase of practically 50 million dollars compared with the same months of last year, while products of the forests show a gain of 10 million dollars, those of the mines about 3 millions, those of fisheries nearly 1 million, and the miscellaneous group over 1 million dollars. The increase in agricultural products occurs chiefly in corn, 16½ million dollars; oats, over 14 millions; wheat, about 23 millions, and flour about 17 millions, while provisions also show a gain of nearly 36 millions. In manufactures by far the largest increase occurs in iron and steel, in which the increase is 20 million dollars. Cotton manufactures show an increase of about 6½ millions; leather and manufactures thereof, an increase of about 2½ millions; cars, carriages, etc., an increase of about 5½ millions, agricultural implements about 2 millions, scientific instruments nearly 2 millions, mineral oil about 3 millions, paper about 1 million, and paraffin about 1 million.

Trade with the non-contiguous territories of the United States also shows an increase in the grand total, but not in merchandise received from the sections thus designated. The total value of merchandise shipped to the noncontiguous territories in the 10 months ending with April is 42 million dollars against 33½ millions in the same months of last year; but the value of the merchandise shipped from those territories to the United States is somewhat less than in the same months of the last year, having been in the 10 months ending with April, 54 million dollars, against 57 millions in the same months of last year, this decrease being due to the fall in the price of sugar. The value of the sugar shipped from the Hawaiian Islands to the United States in the 10 months ending with April is but 19 million dollars,

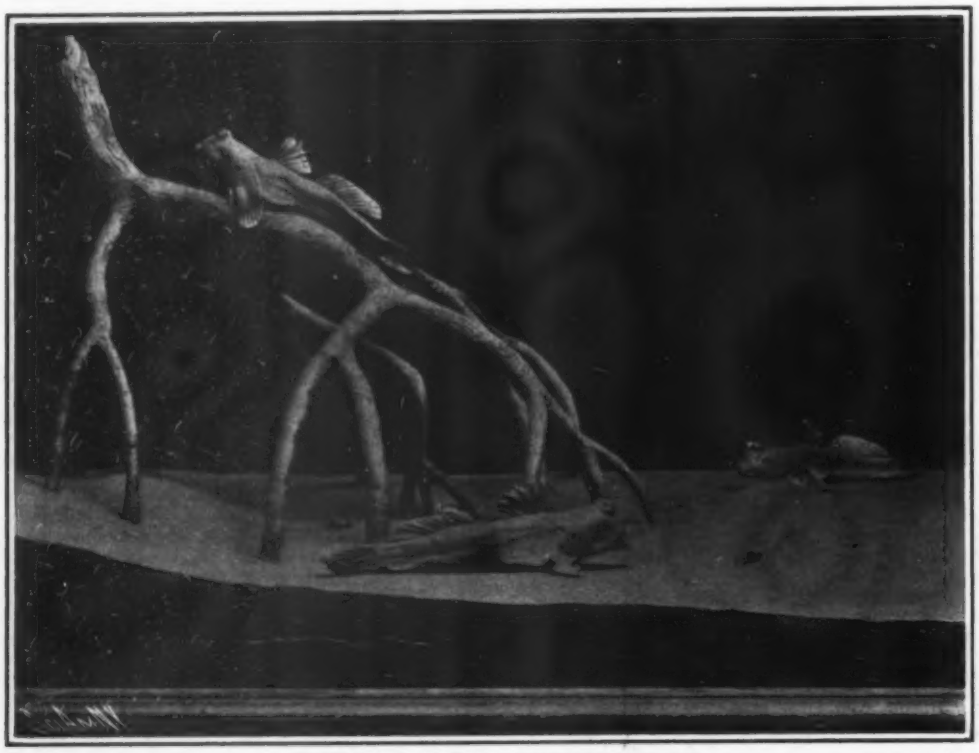
against 24 millions in the same months of last year, the average value per pound during the 10 months of 1906 being about three-fourths of 1 cent per pound below the average for the same months of 1905, thus accounting for the decrease in value of this one item of shipments from the noncontiguous territory to the United States. The figures for the 10 months indicate that the total commerce with the noncontiguous territories will amount to about 115 million dollars, exclusive of approximately 10 million dollars' worth of gold which will be received from Alaska during the full year, the gold figures for the 10 months ending with April having aggregated over 8½ millions.

Summarizing commercial probabilities for the fiscal year which ends with the present month, it may be said that both imports and exports will certainly exceed those of any preceding year, and that the aggregate of trade with the noncontiguous territories will also exceed that of any preceding year; that the increase in imports occurs in all the great groups except foodstuffs; and that the increase in exports occurs in all the great groups, but especially in agricultural products and in manufactures.

## THE MUD-SKIPPER OR JUMPING FISH.

By RANDOLPH I. GEARE.

THIS queer-looking fish illustrates forcibly the power of Nature to adapt her products to their surroundings and requirements. She made them into a fish, but, having decided that they must eat land food, supplied them with the needed facilities for obtaining it. And thus, by the aid of their strong pectoral and neutral fins, and with the assistance of their tail, they can hop freely over the ground, and gather their food, which consists largely of little crabs. The eyes have the appearance of being pushed forward out of their sockets. They can see on land as well as in the water. When drawn back into their natural position, the eyes are protected by a membranous covering.



A PECULIAR SPECIES OF JUMPING FISH.

During the ebb tide these fishes leave the water and hunt for crustaceans, sometimes climbing up on trees or old pieces of timber. The group here shown has been prepared from specimens captured on the mud flats at the mouth of the Sungei Bulu, on the Selangove seacoast in India, by Mr. William T. Hornaday, now director of the New York Zoological Society. He found them exceedingly hard to capture, and the difficulties he met are best described in his own words:

"Although apparently stranded they seemed to feel perfectly at home, and went jumping around over the mud. In reality they were feeding upon the tiny crustaceans left on the bank by the receding tide. . . . There were probably a dozen in sight, hopping spasmodically about, or lying at rest on the mud, but when we made for them they developed surprising energy and speed, and made straight for their burrows. They progressed by a series of short but rapidly repeated jumps, accomplished by bending the hinder third of the body sharply around to the left, then straightening it very suddenly, and at the same instant lifting the front half of the body clear of the ground by means of the arm-like pectoral fins which act like the front flippers of a sea-lion. These fins are almost like arms in their structure and use, the bones being of great length. They were so rapid, and the mud so very deep and our progress so slow, that the fish always succeeded in getting into their holes before we could reach them. By digging a big hole two feet deep, and standing on one's head in the bottom of it, we were able to reach an arm down two feet farther and seize one fish at the bottom of the burrow."

Dr. Francis Day, the eminent English authority on the fishes of India, gives the following account of their habits:

"It is most curious to see these little fishes along the side of the Burmese rivers. At a distance they at first appear stationary, contemplating all passing objects, or else snapping at flies or insects, or in the water they look like a flat stone or a piece of slate sent skimming by a schoolboy. They climb onto the trees and large pieces of grass, leaves, and sticks, holding on by their pectoral fins, exactly as if they were arms. Now and then they plant these firmly as an organ of support, the same as one places one's elbows on a table; then they raise their heads and take a deliberate survey of surrounding objects. They are not very timid; in fact, my interpreter captured several of them by means of quietly creeping up to them and knocking them over with a stick. Occasionally they crawled up to a boat's rope, when moored, and even onto its sides. Some looked light brown with dark bands, others darker, while a few were of a brilliant emerald green, probably due to the position of the body and the reflection of the light. One morning, when at anchor, I saw close to the side of my boat a snake in the water watching one of these fish, which was intently occupied capturing flies. With a stick I saved it from its reptilian foe, but its colors were so vivid I could not resist giving it a place in one of my collecting bottles.

"They are extensively used in Burma for live bait, a purpose for which they appear to be well adapted."

Dr. Gunther says they are brought in considerable numbers into the Bombay markets.

These fishes, like many others, have several names, and the one by which they are most generally known by naturalists is the "goby." They belong to a group which is found in the seas and along the coasts and large rivers of India, Burma, the Andaman Islands, Malay Archipelago, and beyond. They do not occur on either the Pacific or Atlantic coasts of America. One species appears on the west coast of Africa. The body is usually olive brown, with white or blue dots, although, as already intimated, they sometimes appear to assume a bright green hue, which Dr. Day thinks may be due to the reflection of the light.

## GYPSUM—A MUCH MISUNDERSTOOD MATERIAL.*

By ROBERT GRIMSHAW.

THERE are some materials, used in the arts, which are too little understood of men, and among these we may reckon gypsum, or plaster of Paris, which is not only too little understood, but in some connections exactly wrongly understood. In the line of building construction, for example, the word "gypsum" immediately suggests "staff" and temporary structures and decorations, designed and expected to last out at most two winters in a temperate climate. Now as a matter of fact some of the oldest buildings in the world owe their long preservation not merely to favorable climatic conditions and the fact that no great battles were fought about their bases, but to the use of gypsum in their construction. They have not come down to us through the centuries in *spite* of the fact that their builders used plaster of Paris in their construction, but *because* of that fact. As a tolerably well-known building of rather accurately attested age I may instance the pyramid of Cheops, built with gypsum mortar, and which may well recall the bull of the Irishman, "Show me the building of to-day that has lasted as long as those of antiquity!" Surely a building material that has come down through more than four thousand years ought to be good enough for us dwellers in the twentieth century, who think a house that is a hundred years old a piece of antiquity, and calculate on replacing most of the buildings of to-day by others better (or at any rate different) within half a century.

If we go to the island of Crete—the inhabitants of which, according to the more or less lamented Bismarck, still deserve the reputation fastened on them by St. Paul, of being the prize liars of their time—we find the citadel of King Minos, to whom we assign a date "whereof the memory of man runneth not to the contrary," and this citadel is not only built with gypsum mortar but finished in colored gypsum plaster. Any one who has done much prowling around the ruins of North German "burgs" will note that the damp cold climate has had more deteriorating influence upon much of the building stone than on the gypsum mortar employed to bind the stones together.

There is a reason for most things; and for our low appreciation of the durable qualities of gypsum the principal reason is our own ignorance of the manner of preparing and applying the material in question.

As found in nature, gypsum is a hydrated lime sulphate, with the following chemical analysis (Seifer):

| | |
|---|---|
| Lime | 32.5 per cent |
| Sulphuric acid | 46.5 per cent |
| Water of crystallization | 21 per cent |

By driving out the water by means of heat, the constituents are

| | |
|---|---|
| Lime | 41.2 per cent |
| Sulphuric acid | 58.8 per cent |

If we mix the anhydric gypsum with water, the two combine with evolution of heat, reduction of volume, and resumption of hardness.

But there are two processes of dehydrating gypsum, and these yield two widely-differing products; and general ignorance of this fact is the principal cause of the popular impression concerning the instability of plaster of Paris as a building material.

The first process consists in heating the raw gypsum at a comparatively low temperature, with the intention of driving out only a portion of the chemically-contained water. The object of this process is to get a quick-setting plaster, one that will harden in half an hour at most, and that can be used for making casts where delicacy of outline and fidelity of reproduction are the main desiderata.

The other process, carried on at a red heat, has for its object the production of a hydraulic plaster, which shall possess high resistance to the disintegrating influences of moisture and general weathering. Such plaster is much slower setting and much harder than that for stucco and casts, and is purely constructive in its application. It furnishes mortar, flooring, beton mass, and even building-blocks.

A plaster that is dehydrated at a temperature lying between those necessary to produce the "stucco" and "hydraulic" plasters, is neither one thing nor the other, and will not even set when mixed with water.

The burned stucco plaster has in a loose condition a specific gravity of between 0.65 and 0.85; when well shaken down it reaches 1.2 or even 1.4. But in a fully compressed condition the specific gravity is about 2.6.

The hydraulic plaster weighs loosely about as much as water, or ten per cent more; shaken down in a measure, the figures are 1.5 to 1.6; and its proper specific gravity is about 2.85.

The non-hydraulic gypsum remains only a few minutes in a fluid condition, when mixed with the proper proportion of water, and develops considerable heat. The right proportions of water and plaster vary with the quality of the latter material, from say 10 per cent more weight of gypsum, to 60. The plaster is to be strewed in the water and not stirred until the proper quantity has been added; this avoids lumps. Long stirring is not advisable.

Hydraulic gypsum takes less water and is not to be mixed to a thick cream, but rather to a thin dough. The color should be rather yellowish than bluish—the latter color being a sign of over-burning.

Although the analysis of the uncalcined plaster shows only about one-fifth its weight of combined water, the mixture for stucco purposes contains from 90 down to at least 70 per cent. This extra quantity does not remain in the stiffened mass, but gradually evaporates, and in fact often is thrown out in part by sweating. The disappearance of the superfluous water naturally leaves the mass porous. But to get good sharp casts it is desirable to use as much water as possible; particularly because this retards the hardening process. In making molds for porcelain this porosity is desirable, as it facilitates the drying of the creamy mass which is poured in; ceramic work, however, which is molded under pressure, should be made on or in molds which have been made of a stiff mass, as this stands the pressure of molding better.

Plaster should be kept as dry as possible, and dirty water should never be used in mixing, as this reduces the binding property.

A great mistake is adding more water to the mass when it has once got stiff. The stiffness is not the result of lack of water, but is caused by the presence of exactly the right quantity to enter into chemical combination.

In working with hydraulic plaster the strength of the resulting structure depends more on the proper proportion of water than on any other one cause. The great danger is toward excess. The proper amount is

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

determined by experiment; but in general it may be said that only half as much is needed as for stucco work. Care must be taken that during the hardening process no water is drained or absorbed from the mass. It is advisable to have a bed of wet sand on which to work. In order to get the maximum strength, too rapid drying must be avoided; that means avoidance of drafts and of high temperatures.

Stucco plaster swells at the moment of hardening; the increase of volume being about one per cent. This is a great advantage which it possesses in common with cast iron; it gives sharp castings. But if ordinary stucco plaster be employed instead of the hydraulic, the results of this swelling property will be disastrous.

Once hard, neither of the two varieties of gypsum loses its size or shape; but the hydraulic kind differs from the stucco plaster in that it does not swell at the moment of hardening. This is a very desirable property from the point of view of making floors and other large surfaces required to be fully free from drying cracks.

Gypsum which has set is soluble in 400 parts of water. In order, therefore, to protect it from the injurious effects of moisture, the surface of casts, cornices, etc., may be filled with oil paint. Attempts to secure the same advantages by the use of alum, or borax, have proved in the long run futile. There are in Berlin, according to Segar and Cramer, who have collected a mass of material in favor of gypsum for the German Society of Gypsum Manufacturers, façades of stucco which have, by reason of a coat of oil paint, resisted the weather for sixty years.

Hydraulic gypsum, being unaffected by absorption of water into its interior, is indicated for places where weathering is to be expected.

In inspecting ancient buildings where gypsum has been used as mortar between the stones or bricks, the observant investigator will see how much better it has stood the gnawing tooth of time than the lime mortar exposed under similar conditions to the same disintegrating influences.

It will be seen, therefore, that the expression "much misunderstood material" at the head of this article, is particularly applicable to gypsum; and it is to be hoped that our architects and builders will give the old-new building a fair show. To be sure the experiment may remind one of the Irishman who, having heard that a crow would live a hundred years, bought one to try; but it is worth going over the ground which such old master builders as those of the pyramids in the dry climate of Egypt, and the burgs and abbeys of cold and damp Northern Germany, trod with such sureness and success.

## DEVICES FOR DETERMINING THE ENERGY LOSSES IN IRON SHEETS.*

By DR. ALFRED GRADENWITZ.

WHILE some amount of energy is expended in magnetizing iron, the magnetical condition once produced is maintained therein without any consumption of energy, the energy recovered in demagnetizing being smaller than that expended in magnetizing by that part of the molecular energy of the iron which has been converted into heat. Outside of this hysteresis loss some other loss of energy due to what is called Foucault currents will be observed in iron in case of variations in the magnetism. These currents are due to variations in the flux traversing the iron and go in a direction at right angles to the flux, thus being unable to develop to any considerable extent in thin iron sheets. The intensity is proportional to the density of the lines of force ($B$) and number of periods, while the loss of efficiency is proportional to the square of the current intensity and to the ohmic resistance of the conductor, being dependent to a large extent on the shape of the cross-section.

In all kinds of electrical apparatus in which variations in magnetism are produced (e.g., in dynamos and transformers) thin iron sheets are used in building up the iron bodies in order to reduce as far as possible the losses in efficiency due to the phenomena above referred to. Now, since the quality of the iron as regards its electro-magnetic behavior is mainly responsible for the efficiency and the heating of the electrical apparatus, a thorough investigation of the iron used in manufacturing sheet iron for electrical machinery should be of the highest interest.

The importance of a magnetic examination of the sheet iron used in armature disks has been fully appreciated by the Association of German Electricians, which, at its last meeting in 1905, enunciated the following regulations:

"The total loss in iron should be determined by means of wattmeters on samples of at least 10 kilogrammes derived from at least four sheets, and should be stated for $B$ max. = 10,000 and 50 periods in watts per kilogramme for a given temperature. This figure, as reduced to the sinuoidal behavior of the tension curves, is called the 'loss-coefficient' at the temperature in question." The types of apparatus especially recommended by the association are the Epstein (Fig. 1), Möllinger (Fig. 2), and Richter (Fig. 3) apparatus. These three iron-testing instruments are based on the common principle that the iron sample is conveniently shaped to a magnetic circuit, containing exclusively iron of the quality to be tested. The iron sample is next magnetized, winding it with wire and passing an alternating current through it. The effect produced by the alternating current in the windings is measured by means of a wattmeter, in addition to which the current intensity and tension are read by means of instruments of precision, whence the loss coefficient is determined, taking account of the loss of energy in the copper windings and other corrections.

Fig. 4 shows an iron-testing plant recently installed in a metallurgical works in which the Richter apparatus is mainly used. This apparatus enables four complete iron sheets of 1,000 x 2,000 millimeters area to be tested without any loss of metal. The iron sheets are introduced into the drum all together by means of a sliding bar (Figs. 5 and 6) and are thus bent to a cylindrical sleeve surrounded by the magnetizing windings that are drawn out freely through the air. The direct current-alternating current transformer visible in Fig. 4 is used as source of current; this is operated from a special accumulator battery so as to obtain a constant number of turns throughout each test. The frequency and pressure of the alternating current are readily altered within wide limits so as to separate the ascertained losses into those due to hysteresis and Foucault currents respectively. Any necessary apparatus for inserting and regulating the transformer (switches, fuses, ammeters, voltmeters, frequency meters, and regulation resistances) are installed on the marble switchboard. The readings proper of the intensity, tension, and output on which the determination of the loss coefficient is dependent, are made on the instruments of precision installed on the table and which, independently of the displacement in phase, record the number of periods and shape of current curve; they are of the dead-beat type. The precision wattmeters have been so designed as to reach the terminal deflections with full current and tension load for cos $\varphi = 0.5$, thus considerably increasing the accuracy of the reading.

In Fig. 7 is shown a similar testing station of another rolling mill in which the Epstein apparatus is exclusively used. In this apparatus the sheet to be tested should be cut into strips of given length and breadth, which strips are insulated from each other by wrapping them with silk paper and are combined in a substantial package by winding them with insulating tape. The four packages are next introduced into the four magnetizing coils and the magnetic circuit closed by tightening the wooden jaws. Any immediate contact of the side joints is prevented by inserted pieces of fiber. The transformers and instruments used in connection with these iron-testing plants are so designed and provided with such ranges as to allow the measurements to be carried out both with the Richter and Epstein apparatus.

The third testing apparatus referred to above, viz., the Möllinger instrument, comprises an iron core made up of punched iron rings. This apparatus requires no joints which might permit leakage, as the continuous core is surrounded by a detachable coil. The apparatus is used to special advantage in connection with the current iron tests made in electrical works, employing sheet rings as used in the current types of dynamos. As these sheet rings can be put to service

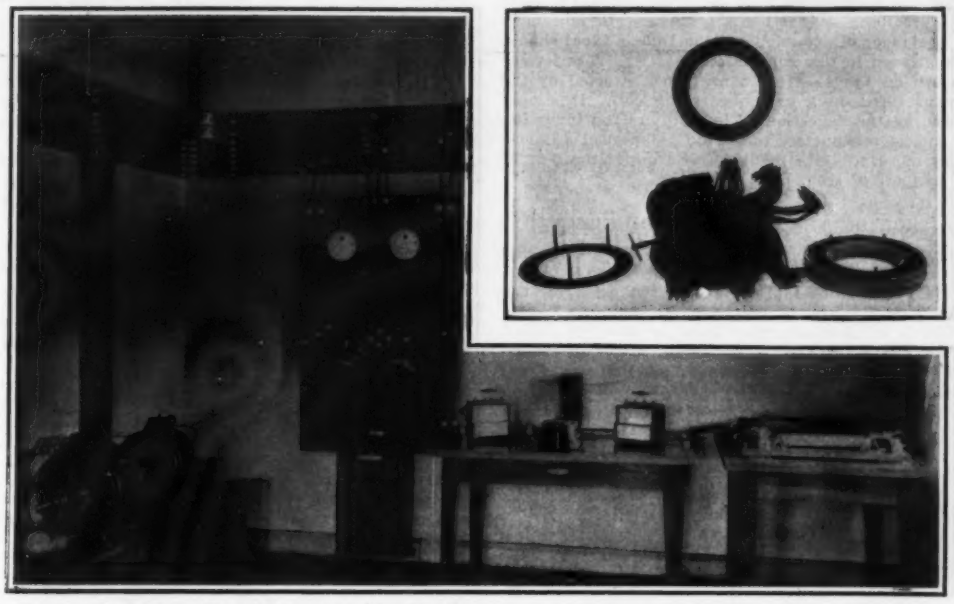
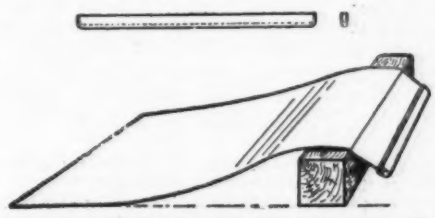


Fig. 7.—Plant Using Epstein Apparatus for Testing Energy Losses in Iron Sheets.



Fig. 2.—The Möllinger Type of Testing Apparatus.



Figs. 5 and 6.—Sliding Bar for Introducing Iron Sheets in Richter Apparatus.

Fig. 8.—Dubois Magnetic Balance.



Fig. 3.—The Richter Testing Apparatus.



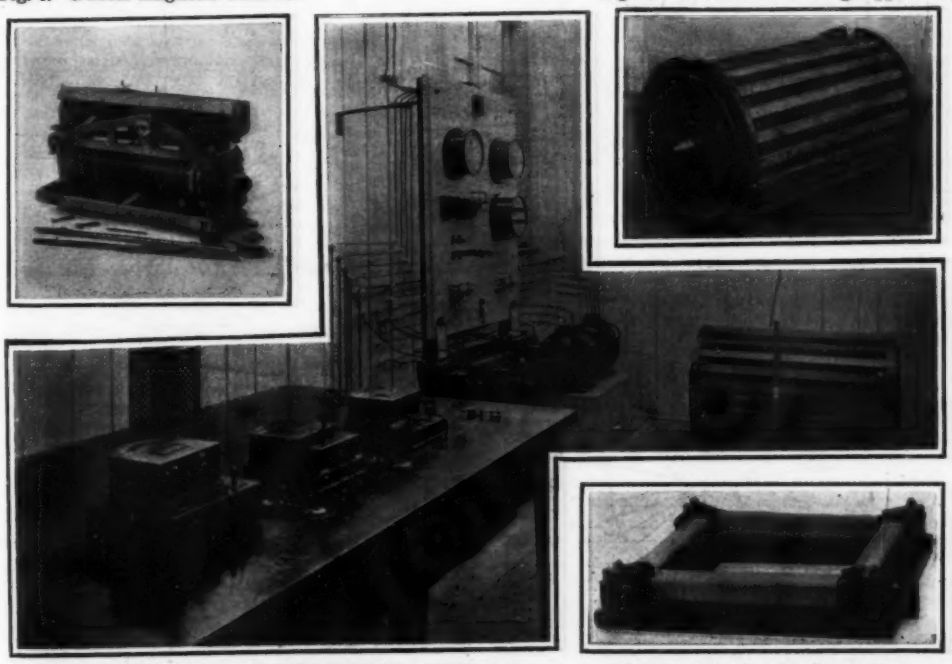


Fig. 4.—Iron Testing Plant Using Richter Apparatus.



Fig. 1.—The Epstein Apparatus.



*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

after the measurement has been completed, there is no loss of either material or of wages.

Outside of the wattmeter test referred to, those types of apparatus which allow the iron losses to be ascertained magneto-statically by means of the hysteresis are likewise used for the same purpose in technical practice. Magnetizing arrangements and magnetic balances of precision (of the Dubois type) should be mentioned in this connection (Fig. 8). The former is based on the electro-dynamic effect exerted by the lines of force on a current-carrying coil. It simply records by the deflection of its pointers the induction per square centimeter, while the magnetical balance, giving more accurate readings, determines the pull of the magnetized iron.

## CONTROL OF THE DIRECTION OF ELECTRIC WAVES.*

By WILLIAM MARCONI, LL.D., D.Sc.

THIS note relates to results observed when for the usual vertical antenna employed as radiator or absorber in wireless-telegraph stations there is substituted a straight horizontal conductor placed at a comparatively small distance above the surface of the ground or water.

When an insulated horizontal wire (*AB*), such as

FIG. 1.

is shown in Fig. 1, is connected at one end to a sphere of a spark gap, the other sphere of which is earthed, and sparks are caused to pass between the spheres, it will be noticed on investigating the space around such an oscillator that the radiations emitted reach a maximum in the vertical plane of the horizontal wire, *A B*, and proceed principally from the end, *A*, which is connected to the spark gap, while the radiation in *nil*, or reaches a minimum, in directions which are approximately 100 degrees from the direction in which the maximum effect occurs.

I have also noticed that any horizontal conductor of sufficient length placed upon or at a short distance above the surface of the ground, and connected at one end through a suitable detector to earth, will receive with maximum efficiency only when the transmitter is situated in the vertical plane of the horizontal receiving conductor, and in such a direction that the end connected to the detector and to the ground is pointing toward the transmitting agency.

If, therefore, such a horizontal conductor be swiveled about its earthed end in a horizontal plane, the bearing or direction of any transmitting station within range of the receiver can be ascertained.

I have carried out a number of tests with transmitters and receivers having radiating or receiving antennæ or conductors arranged as follows:

(1) Transmitting conductors consisting of horizontal wires, the radiations being received at a distance by means of the usual vertical wires suitably attuned.

(2) Both transmitting and receiving conductors consisting of horizontal wires.

(3) Transmitting conductors consisting of one or more vertical wires, with or without capacity areas at the top, such as have been generally employed in wireless telegraphy, the radiations being received by means of horizontal conductors.

At long distances I almost invariably used as a

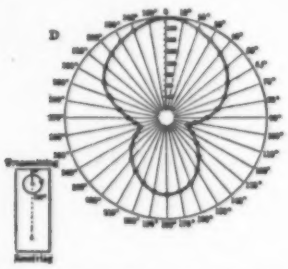



FIG. 2.—CURVE SHOWING OBSERVED CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Horizontal, rotating from 0 deg. to 360 deg., 1.5 meters above ground. Receiving Conductor: Vertical, fixed, height, 18 meters. Length of Transmitting Conductor, 60 meters. Receiving Conductor, 18 meters. Distance of Transmission, 260 meters.

detector my magnetic receiver.† At shorter distances I utilized a Duddell thermo-galvanometer‡ by means of which it was possible to measure the root-mean-square values of the currents induced by the oscillations in receiving wires disposed in various positions relative to the transmitting conductors.

With arrangements such as are referred to in (1) the following tests have been carried out:

1. Transmitter.—Horizontal wire 100 meters in length, direct excitation, spark length two centimeters, wave length approximately 500 meters.

Receiver.—A vertical wire eight meters in length, tuned to the period of the transmitter by means of a syntonizing coil, and connected to a magnetic detector, and to earth in the usual manner.

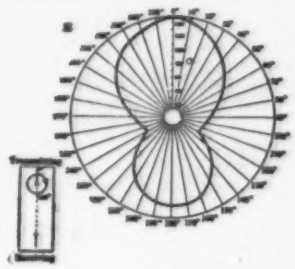



FIG. 3.—CURVE SHOWING OBSERVED CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Horizontal, revolving from 0 deg. to 360 deg., 1.50 meters above ground. Receiving Conductor: Horizontal, fixed, 1.50 meters above ground. Length of Transmitting Conductor, 60 meters; Receiving Conductor, 60 meters. Distance of Transmission, 260 meters.

Results.—Signals quite distinct at 16 kilometers in the vertical plane of the horizontal transmitting wire and in the direction of its earthed end; weak at 10 kilometers in the same vertical plane, but in the reverse direction; inaudible at six kilometers at right angles to the directions above mentioned.

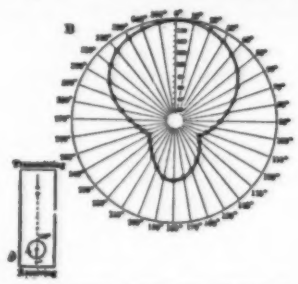



FIG. 4.—CURVE SHOWING OBSERVED CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Horizontal, fixed, 1.50 meters from ground. Receiving Conductor: Horizontal, rotating from 0 deg. to 360 deg., 1.50 meters from ground. Length of Transmitting Conductor, 30 meters; Receiving Conductor, 30 meters. Distance of Transmission, 225 meters.

2. Transmitter.—At Mullion, Cornwall; consisting of horizontal conductor 150 meters in length, composed of four parallel wires about three millimeters in diameter, placed 1.50 meters apart, supported at a height of 20 meters, and all connected to earth through the spark gap of an induction coil placed in a building on the ground; spark length about two centimeters.

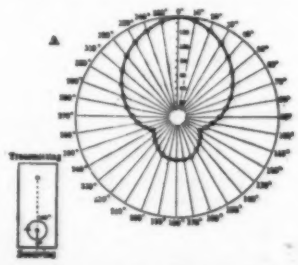



FIG. 5.—CURVE SHOWING OBSERVED CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Vertical, fixed; height, 44 meters. Receiving Conductor: Horizontal, rotating from 0 deg. to 360 deg., 1.50 meters above ground. Length of Transmitting Conductor, 45 meters; Receiving Conductor, 30 meters. Distance of Transmission, 680 meters.

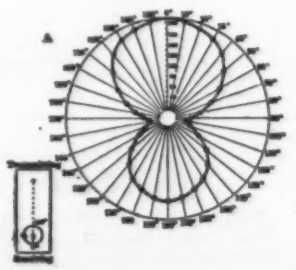



FIG. 6.—CURVE SHOWING OBSERVED CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Vertical, fixed; height, 44 meters. Receiving Conductor: Horizontal, rotating from 0 deg. to 360 deg. on ground. Length of Transmitting Conductor, 45 meters; Receiving Conductor, 30 meters. Distance of transmission, 680 meters.

Receiver.—At the Haven, Poole (distance 240 kilometers); consisting of vertical wire 50 meters long, connected through a syntonizing coil to a magnetic detector and to earth.

Results.—A movement of 15 degrees of the plane of the transmitting conductor out of the right direction was sufficient to cause signals to become indetectable at Poole.

Polar diagram, *D* (Fig. 2) gives the values of the received current in micro-amperes, with conditions as marked under the diagram. The values of current in micro-amperes shown in each diagram are the mean of a considerable number of readings, the transmitted energy being kept as nearly as possible constant by means of a suitable interrupter applied to the sending induction coil.

With the arrangement mentioned at (2), i. e., both transmitting and receiving conductors horizontal, the following results, among others, were obtained:

1. Transmitter.—Conductor 200 meters in length, supported at a height of 15 meters above ground; spark length about two centimeters.

Receiver.—Similar conductor supported one meter above ground connected at one end to a detector and to earth as usual.

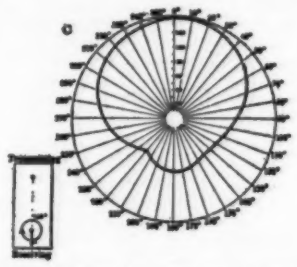



FIG. 7.—CURVE SHOWING CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Poldhu Station Aerial, consisting of multiple vertical Conductors with large capacity at the top. Receiving Conductor: Horizontal, rotating from 0 deg. to 360 deg., 1.50 meters above ground. Length of Receiving Conductor, 30 meters. Distance of Transmission, 650 meters.

Results.—In the direction for maximum effect (as already explained) readable signals at 25 kilometers. At about 90 degrees from said direction at 12 kilometers, nothing; in the same direction at five kilometers, weak signals.

2. Transmitter.—Consisting of four wires, each 330 meters in length, separated from one another by a distance of 1.4 meters, supported at a height of 20 meters above ground and connected by means of a nearly vertical conductor to a spark producer; spark length, three centimeters.

Receiver.—Consisting of one wire 220 meters in length, covered with insulating material, placed on the ground and connected to the end nearest the sending station through a syntonizing coil to a magnetic receiver, and to earth.

Results.—When in the vertical plane of the transmitting antennæ, and in the best direction, weak but distinct signals were received at a distance of 160 kilometers; at 45 degrees from said direction and at 150 kilometers distance, nothing was received; at 25 degrees from the best direction, and at 160 kilometers distance, very weak signals were received.

The results over shorter distances are given by the readings obtained on the thermo-galvanometer, and are shown in the polar diagrams *E* and *B* (Figs. 3 and 4).

With arrangements such as are mentioned at (3), i. e., the transmitting conductor consisting of the usual vertical type and the receiving conductor horizontal, the following results among others merit attention:

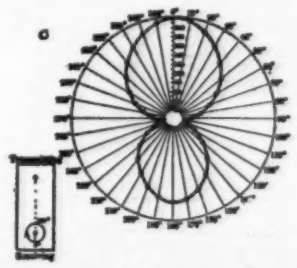



FIG. 8.—CURVE SHOWING OBSERVED CURRENT IN MICRO-AMPERES AT EARTHED END OF RECEIVING CONDUCTOR UNDER THE CONDITIONS OF DIRECTION SHOWN BELOW.

Transmitting Conductor: Poldhu Station Aerial, consisting of multiple vertical Conductors with large capacity at the top. Receiving Conductor: Horizontal, rotating from 0 deg. to 360 deg. on ground. Length of Receiving Conductor, 30 meters. Distance of Transmission, 650 meters.

At Clifden, Connemara, Ireland, by means of a horizontal conductor 230 meters in length, laid on the ground and connected at one end to a magnetic receiver and to earth, it is possible to receive with clearness and distinctness all the signals transmitted from the Poldhu station (situated 500 kilometers distant) provided that the free end of the conductor points directly away from the direction of Poldhu. No signals can be received if the horizontal wire at Clifden makes an angle of more than 35 degrees with the line of direction of Poldhu.

The signals from the Admiralty station at Scilly can be received at Mullion, Cornwall (distance about

* A paper read before the Royal Society, March 22. Communicated by Dr. J. A. Fleming. From the London Electrician. The full title of this paper is: "On Methods Whereby the Radiation of Electric Waves May be Mainly Confined to Certain Directions, and Whereby the Receptivity of a Receiver May Be Restricted to Electric Waves Emanating from Certain Directions."

† See Proceedings of Royal Society, London, 1902, vol. lxx., p. 341.

‡ Philosophical Magazine, 1904, vol. viii., p. 91.

85 kilometers), by means of a horizontal wire 50 meters in length, two meters above ground, provided the wire is placed in a radial position with respect to the sending station and with its free end pointing away from it. But it is unreceptive if placed so as to make an angle of more than 20 degrees with the line of direction of the station at Scilly.

Some tests have also been carried out for the Admiralty in the vicinity of Poldhu, in conjunction with H. M. S. "Furious." For this purpose eight horizontal wires 60 meters in length, supported at a height of about two meters, were arranged radially and made to converge in a small building, situated in a field near Poldhu. These radial wires were so arranged as to divide the circle into eight equal sectors. By means of a suitable switch any one of the ends of these wires at the position where they converge together could be connected to earth through a magnetic receiver.

The wireless telegraph station on the "Furious" consisted of an ordinary vertical-wire aerial about 50 meters in length, connected to a suitable spark-gap. The station on the ship transmitted at intervals, and the ship followed a course describing an arc of about 180 degrees round Poldhu, keeping at distances varying up to 16 miles. By means of the horizontal wire arrangement the bearings of the ship from Poldhu could be determined at any time by noting on which particular wire or wires the reception of signals was strongest, and also by observing which wires were non-receptive.

It was also found possible to receive simultaneously and without mutual interference different signals sent by means of oscillations of the same wave-length coming from the ship and from the Lizard wireless station (10 kilometers away) whenever the ship was in such a position that its bearing from Poldhu made an angle of at least 50 degrees with the bearing of the Lizard station.

For further values and curves of received current in receivers I refer to diagrams *A*, *A'*, *C*, *C'*. (Figs. 5, 6, 7 and 8.)

Referring generally to the results mentioned in this note, I have observed that, in order that the effects should be well marked, it is necessary that the length of the horizontal conductors should be great in proportion to their height above the ground, and that the wave-lengths employed should be considerable—a condition which renders it difficult to carry out such experiments within the walls of a laboratory.

I have found the results to be well marked for wave-lengths of 150 meters and over, but have not been able to obtain as well-defined results when employing much shorter waves—the effects following some law which I have not yet had time to investigate. There also appears to be a decided advantage, in so far as effects at long distances are concerned, in utilizing a directly excited radiating conductor—that is, an insulated conductor in which the high-frequency oscillations are started by means of a suitable spark discharging it to earth or to another body, as was usual in my early forms of Hertzian-wave wireless-telegraph transmitters.

If inductive excitation is employed, that is, if the oscillations are induced in the radiating conductor from another oscillating circuit, the comparative results in various directions appear to be in the same proportions as those noticed when using the method of simple excitation, but the distances over which the effects can be detected are much smaller at parity of the power employed at the transmitter.

I have noticed that the most advantageous length of the receiving horizontal wires, in order to obtain results at maximum distances, is about one-fifth of the length of the transmitted waves if the wires are placed at a distance above the ground; but the receiving wires should be shorter if placed on the ground. It would be instructive to investigate more thoroughly the difference of the results and curves obtained by means of horizontal wires placed at different heights above ground and also the effect of varying the length of the wires.

When using horizontal receiving wires arranged as described in this note I have often noticed that the natural electrical perturbations of the atmosphere or stray electric waves, which are generally prevalent during the summer, appear to proceed from certain definite directions, which vary from time to time. Thus, on certain days the receiving instruments, when connected to wires which are oriented in such a way as to possess a maximum receptivity for electric waves coming from the south, will give strong indications of the presence of these natural electric waves, while on differently oriented wires the effects are at the same time weaker or imperceptible. On other days these natural electric waves may apparently come from other directions.

It would be exceedingly interesting to investigate whether there exists any relation between the direction of origin of these waves and the known bearing or direction of distant terrestrial or celestial storms, from whence these stray electric waves most probably originate. A considerable number of observations would be necessary to determine whether there exists any relation between the bearing of storm centers and the direction of origin of these natural electric waves. I propose to carry out some further investigations on the subject.

I ought to explain that the experiments described in this note were carried out during a period of many months, and that as other results achieved over great distances coincide generally with those here described, I have not thought it necessary to make special reference to them.

I should also mention that the tests over short distances were carried out over practically flat country, while over considerable distances they took place over hilly country, such as the West of England, and in some cases partly across sea and partly across land.

## ENGINEERING NOTES.

**The great attraction** of the gas power plant is its high fuel economy. The modern suction producer plant, using coke as fuel, and direct-coupled to an electrical generator has been shown to generate a kilowatt for 1,325 pounds of fuel per hour, the thermal efficiency of the plant being over 22 per cent, and the ratio of electrical energy to the heat energy in the fuel reaching as high as 20.8 per cent.

**That clean blast furnace gas** is by far more advantageous in its use than dirty gas, is shown by an experience had at the blast furnace plant at Seraing. After cleaning a boiler and putting it into commission again, it required with dirty gas three hours time to get up the steam pressure, while by using clean gas, this time could be reduced to one and one-half hours. It is a well-known fact that clean gas burns far better than gas containing considerable quantities of very fine dust. In Europe, the centrifugal gas cleaning apparatus invented by Edward Theisen is used almost exclusively for gas cleaning plants. This apparatus requires for a given amount of gas, less power, less water, and less attendance and is giving far better results than the so-called hydraulic fans which were used six years ago.

**The gradual extension** of the practice of making the top of the locomotive fire-box and casing flat, instead of round, is noticeable. On the Great Western Railway less trouble has been experienced with the flat-top fire-box than with the round-top, although no sling-stays of any kind are used. The flat-top has the important advantage of increasing the area of the waterline at the hottest part of the boiler, and so materially contributes to the reduction of foaming. This, combined with the coned connection to the barrel, has enabled the dome, always a source of weakness, to be entirely dispensed with and drier steam obtained. The liberal dimension of 2 feet between the top of the fire-box and the inside of the casing no doubt contributed to the satisfactory result. The coned barrel connection, in addition to providing a greater area of water line, also gives a larger steam capacity, and, by the larger diameter being arranged to coincide with the line of the fire-box tube-plate, much more water space at the sides of the tubes is possible. On consideration of the great intensity of temperature at the fire-box plate, as compared with that at the smoke-box plate, the advantage of the arrangement is obvious.

**The monetary aspect** of sewage farming has an important bearing upon the success or otherwise of the treatment afforded. Farms in general cannot be expected to yield a profit if interest on capital expenditure is taken into account, although during favorable seasons with good cropping, the working expenses may be more than covered. But herein lies the danger which makes for failure if not carefully guarded against. The farm, it must be remembered, is for the purpose of the disposal of the sewage of the town, and the growing of crops is to be regarded as a means of cleansing and recovering the purifying power of the land in order that it may be again brought into a suitable form for the receipt of more sewage upon it. Provided it is properly handled, land will continue satisfactorily to purify sewage for a practically indefinite period, and there are many farms in use to-day which have been satisfactorily operated for purposes of sewage purification for the past thirty years. But successful working involves continuous intelligent management, and a sufficient area of suitable land. The sewageable area of land must be increased in proportion to the increase in population served by the farm, in the same way that any other works require to be extended and adjusted from time to time to the increasing amount of work demanded of them.

**Experiments are being conducted** in Australia with a new method of destroying rabbits in their warrens, and which in some districts are so numerous as to constitute a serious pest. The apparatus comprises a portable steam boiler of small and special design, so as to facilitate transport over broken ground, and a length of flexible metallic hose. If desired, several lengths of hose can be connected to the steam boiler, so that a corresponding number of burrows may be treated simultaneously. The mouth of the hose is carried into the open burrow, which is then tightly and securely sealed up. The steam is passed into the animal's home under pressure and at a high temperature, and the inmates unable to escape are rapidly killed. Results with this system have been carried out on several farms in Victoria, especially in the Picola district, where the pest was abnormally prolific, and has proved so successful that the scourge has been exterminated on many farms. One great advantage of the system over poisoning expedients is that no damage is caused to useful birds, which might be unavoidably destroyed through partaking of the contaminated bait, while at the same time, as the animals are killed in the warrens, the farmers are spared the expense of disposing of the carcasses. Owing to the small, compact nature of the plant and its lightness, it is easily transported from one point to another, while the speed with which the burrows can be treated enables a wide area of rabbit-infested land to be cleared in a day.

## WHITE CEMENTS.

ALTHOUGH the various hydraulic cements possess many valuable properties all of them suffer, more or less, from a defect which becomes unpleasantly conspicuous in certain of their applications. This defect is the color peculiar to the variety of cement employed. I am not now referring to discoloration of the surface by the exfoliation of various salts during the course of hardening. These exfoliations are chiefly due to an injudicious selection or treatment of the raw materials and can therefore be prevented by the exercise of proper care.

But most cement has an unsightly and often diversified proper color. Roman cement, for example, is pale yellow, brown or gray, while the color of Portland cement is a gray of more agreeable character and of various shades. Some slag cements are almost white in the first stage of hardening but afterward turn to a blue-gray which gradually becomes darker.

The colors of these cements prevent their employment for many purposes for which they are otherwise well adapted. For example, if it were possible to make a pure white cement possessing all the good qualities of the hydraulic cements the manufacturers of artificial marble would not be compelled to use magnesia cement, which is unreliable, or plaster of Paris, which will not stand exposure to the weather. Imitations of natural conglomerates with a white basis are also rendered visibly inferior to the natural stones by the color of the cement which must be employed in their manufacture, and the production of a good white cement would solve the problem, not only for white, but for all other colors, for the white cement could be colored to any desired tint by the admixture of comparatively small quantities of pigments. With ordinary cement, on the contrary, it is usually necessary to use a very large amount of coloring matter in order to cover the gray or brown tint and produce clear tones.

The chief difficulties encountered in the production of white cements are met with in the choice of the raw materials. These must, above all else, possess the properties of the materials used in making ordinary cements but, in addition, they must be free from all substances which either are naturally colored or develop color in burning. The most important of these impurities are iron and manganese. Many varieties of limestone satisfy these conditions very well but most of the marls and clays which are commonly used in cement making contain considerable quantities of iron. On the other hand, clays free from iron, such as the kaolin used in making porcelain, are very expensive and furthermore, in consequence of their high sinter point, they combine with the lime during the firing far less readily than do the more fusible clays which contain iron.

Notwithstanding these difficulties a great many attempts have been made to produce white cements. Very strangely—though the same thing has happened in many other technical fields—the most difficult problem was attacked at the outset, the making of white Portland cement. Many patents have been granted for such cement but very little of it has been made until quite recently.

Julius Gresly, director of the Swiss Cement Works of Liesberg, on the other hand, confined his endeavors to the production of white artificial Roman cement. This is a much easier task, because the temperature of Roman cement in the process of burning is kept below the sinter point. Gresly took as models for imitation the best French Roman cements which have an average composition of 23 parts silica, 13 parts clay and oxide of iron, 59 parts lime and magnesia, and 3 parts sulphuric acid. By using kaolin, marble, and gypsum, all free from iron, Gresly succeeded in making a white Roman cement of the same composition as that given above, except that the iron oxide was replaced by additional clay and the magnesia by additional lime, the properties being 23 parts silica, 13 parts clay, 29 parts lime, and 3 parts sulphuric acid. The gypsum, however, may be omitted.

The mixed ingredients, heated to a temperature below the sinter point—in technical language "between seggers 3 and 6—coalesced into pure white lumps. In this form the product could not be slaked with water but when ground it showed all the properties of an excellent hydraulic cement. The only difficulty encountered was in the burning. At first the kaolin and the lime appeared reluctant to react on each other but the difficulty was overcome by the addition of a very small quantity of gypsum.

The cement made by this process and known commercially as Liesberg white cement is adapted for use in all cases where it is desired to combine the properties of hydraulic cement with perfect whiteness or a pure tone of any color, produced by the admixture of pigments. The cement sets quickly and may be flooded with water immediately after setting. It must, therefore, be worked rapidly and this appears to be its only defect. It is strong enough to take up a great deal of pigment without injury and gives soft and pleasing tints. As the color becomes softer after the cement has set more pigment must be used than the color of the wet mass would indicate, but ultramarine must be employed with caution, because of its great coloring power. In making colored mortars the white cement and pigment should be mixed dry before the sand and water are added.

Liesberg white cement will probably find its principal employment in the artificial stone industry. The most delicate tints of red sandstone, for example, can be imitated to perfection. As the white cement mor-

tar hardens very quickly the largest blocks of artificial stone can be removed from the molds and the latter refilled in an hour or two after the blocks are cast. When quite new the blocks are easily sawed and planed but they soon become as hard and weather-resisting as the best natural stone. This excellent property may be intensified by sprinkling the blocks with water two or three times a day in the first stage of hardening.

For facing buildings, also, this cement appears to offer many advantages, as it is adapted both for stucco work and for making colored tiles. In many cities, especially in south Germany, a movement is on foot which is directed toward the revival of the polychrome façades of the Middle Ages. It is true that the use of cement for this purpose requires very skillful workmen who must combine the talents of sculptors and painters. In decorative carving in white as in other cement care must be taken that the surface to be decorated is clean, saturated with water and not too smooth. Work with chisel and graver may be begun an hour after the coating of cement has been applied to the façade.

The white cement is also very well adapted to making casts. The mortar fills the mold completely, sets quickly and in a few days becomes perfectly weatherproof. Defects are easily remedied by patching with the same composition, and the parts so added become as hard as the rest, to which they adhere firmly. Pure white casts having the appearance of marble are made of the white cement mixed with pulverized glass, instead of sand, and any other stone can be imitated by substituting that variety of stone, in powder. As the white cement does not set as quickly as plaster, large castings can be made by a single workman. Polychrome castings can be produced with ease.

Objects made of Liesberg white cement were shown at the first German exhibition of manufactures of clay, cement and lime and a gold medal was awarded to its inventor at the recent world's fair in Luttich.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Tonindustrie Zeitung.

[Concluded from SUPPLEMENT No. 1589, page 25466.]

## PRIMERS AND FUZES FOR CANNON.—II.*

By Major ORMOND M. LISSAK, Ordnance Department, Instructor of Ordnance and Gunnery, U. S. M. A.

### FUZES.

FUZES are the means employed to ignite the bursting charges of projectiles at any point in the flight of the projectile or on impact.

They are of three general classes:

Time fuzes.

Percussion fuzes.

Combination time and percussion fuzes.

All fuzes should be simple in construction, safe in handling, certain in action, and not liable to deterioration in store. In addition the rate of burning of the time train of the fuze must be uniform.

The time fuze alone, that is, without percussion element, is no longer used in modern ordnance.

*Percussion Fuzes.*—A percussion fuze is one that is prepared for action by the shock of discharge, and that is caused to act by the shock of impact.

When ready to act, as after the shock of discharge, the fuze is said to be armed.

Percussion fuzes are inserted at the point or in the base of the projectile. In some of the projectiles for guns of minor caliber, including the 6-pounder, the fuze is inserted at the point; in others at the base. The percussion fuzes for field, siege and seacoast projectiles are base insertion fuzes.

The percussion fuze consists essentially of the case or body of brass, which contains and protects the inner parts and affords a means of fixing the fuze in the projectile; the plunger, carrying the firing pin and provided with devices to render the fuze safe in handling; the percussion composition, which is fired by the action of the plunger on impact; and the priming charge of black gunpowder.

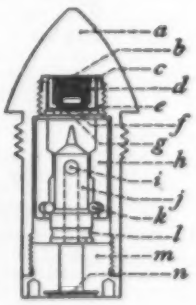



FIG. 15.

The percussion composition of all service fuzes manufactured at Frankford Arsenal is the same. The ingredients are chlorate of potash, sulphide of antimony, sulphur, ground glass and shellac. The thoroughly pulverized ingredients are mixed dry, and alcohol is added to dissolve the shellac. The percussion pellets are formed by pressing the mixture while in a plastic state into the percussion-primer recess. Upon the evaporation of the alcohol, the shellac causes the pellet to adhere to the metal of the recess.

A mercuric fulminate percussion composition was formerly used in fuze primers, but on account of the danger incident to handling this compound it has been abandoned as a primer ingredient.

It is still used abroad, and the percussion composition of both the Ehrhardt and Krupp combination time and percussion fuzes contains mercuric fulminate.

*Point Percussion Fuze, for Minor Caliber Shell.*—These are adapted to the projectiles for 1-pounder, 2-pounder, and 6-pounder guns.

The body *a*, Fig. 15, is of brass. Into the recess formed in the head is screwed the cup-shaped primer screw *e*, Fig. 17, into which are previously assembled first the brass primer shield *g* and then the primer cup

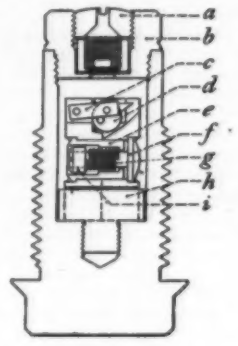



FIG. 16.

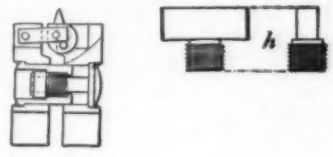



FIG. 20.

FIG. 21.

*d*, Fig. 17, containing the percussion composition *f* and the charge of black powder, *c*. A tin-foil disk *b* closes the mouth of the primer cup. The primer screw *e* has a central hole through the bottom which permits the firing pin to reach the percussion composition. The primer shield *g* prevents any dislodgment of the composition during transportation, or by shock of discharge, and also restrains the firing pin during flight of the projectile. The primer cup *d* has two chambers separated by a solid partition, through which are bored two circular vents. The lower chamber, 0.03 inch deep, holds the percussion composition, and its wall is undercut to assist in holding the composition in place. The primer cup is 0.03 of an inch longer than the recess in the primer screw *e*, so that

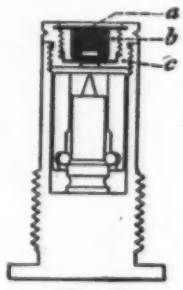



FIG. 18.

when the latter is screwed down hard the primer cup bears against the head of the fuze body.

Contained in the body of the fuze is the plunger, which consists of the firing pin *j*, the firing-pin sleeve *h* and the split-ring spring *k*, all of brass. The firing pin has an enlarged rear part joined to the forward part by conical slope, and provided near the bottom with a groove *l* of diameter slightly larger than the diameter of the forward part of the pin. A radial hole *i* through the pin near its forward end, and an axial hole from this point to the rear end of the pin, provide a passage for the flame from the priming charge. The rear part of the bore through the sleeve, *h*, is of diameter just sufficient to admit the split ring, which rests against the forward shoulder of the counterbored recess, and holds the firing pin so that its point is wholly within the sleeve. The front part of the sleeve is counterbored to permit ready entrance of the flame from the priming charge into the passage through the firing pin. The plunger thus assembled is placed in the fuze body, which is closed by the brass closing screw *m*, provided with a central vent which is in turn closed by the brass disk *n*. To prevent pressure of the closing screw on the plunger, which might cause expansion of the split ring and the arming of the fuze, the plunger is allowed a longitudinal play in the fuze body of from one to two-hundredths of an inch. With the parts of the fuze in this position the point of the firing pin is prevented from coming into contact with the percussion composition, and, therefore, the fuze cannot be fired.

If sufficient force is applied rearwardly to the sleeve, *h*, the split ring, *k*, will be forced over the enlarged portion of the firing pin until it rests in the groove *l*, near the bottom; and the sleeve, moving to the rear, will expose the point of the firing pin. The fuze is then armed, as shown in Fig. 16.

To insure arming of the fuze when fired, the resistance of the split ring to expansion is made less than the force necessary to give the sleeve the maximum acceleration of the projectile. Therefore, when the piece is fired and while the projectile is attaining its maximum acceleration, the pressure of the sleeve will force the ring over the enlarged part of the firing pin into the groove at the rear.

The diameter of this groove being greater than the diameter of the front part of the firing pin, the ring is now expanded into the counterbored recess in the sleeve and locks the sleeve and firing pin together, with the point of the firing pin projecting beyond the sleeve.

As the plunger of the fuze does not encounter the atmospheric resistance which retards the projectile in its flight, it is probable that during the flight of the projectile the plunger moves slowly forward until the point of the firing pin rests against the brass primer shield.

At impact of the projectile the combined weight of the plunger parts acts to force the point of the firing pin through the primer shield and into the percussion composition, igniting the composition.

The flame from the primer charge passes through the forward vents, through the passages in the plunger, and through the vent in the closing screw, blowing out the closing disk and igniting the bursting charge in the shell.

*Base Percussion Fuze*, for minor caliber shell. This fuze, as well as the point percussion fuze, is adapted to the projectiles for 1-pounder, 2-pounder, and 6-pounder guns.

The fuze, Fig. 18, is similar in construction and action to the point percussion fuze. As the primed end of the fuze is toward the interior of the shell the flame from the priming charge passes directly to the bursting charge in the shell, without passing through the body of the fuze. The flame passages through the plunger parts are therefore omitted. The primer cup *b* containing the percussion composition and priming charge is closed at its outer end by the brass disk *a*, which is secured in place by crimping over it a thin wall left on the brass closing cap screw *c*.

There are two classes of ring-resistance fuzes manufactured, the "high resistance" and the "low resistance," so called because the arming resistance of the ring is relatively high or low.

High-resistance fuzes are safe under all ordinary conditions of handling and transportation, and are transported fixed in the projectiles in which used.

Low-resistance fuzes cannot, on account of the danger of premature arming, be transported fixed in projectiles.

The low-resistance fuzes are transported packed in hermetically sealed boxes, and, to prevent premature arming of the plunger in handling, the firing-pin sleeve and the firing pin are locked together by means of a safety wire passing through them and the body of the fuze. Just before using this wire must be pulled out, after which the fuze may be screwed into the projectile. The only low-resistance fuze at present issued is the 28-second combination fuze, for 7-inch mortar shrapnel.

The act of arming a ring-resistance percussion fuze shortens the plunger and increases materially its longitudinal play in the fuze body. This fact permits a ready and simple means of inspecting for premature arming without dismantling the fuze. If the fuze be held close to the ear and shaken, the marked difference between the play of the plunger in an armed fuze and in an unarmed one can be readily discerned.

*Percussion Fuzes for Larger Projectiles. Centrifugal Fuzes.*—The centrifugal fuze of service pattern is the result of a long series of experiments made for the purpose of developing a fuze that would fulfill the requirements of absolute safety in handling and transportation, and certainty of action.

In the case of ring-resistance fuzes, or any fuze the action of which depends on the longitudinal stresses

FIG. 17.

* Prepared for the cadets of the United States Military Academy and published in the Journal of the United States Artillery.

developed by the pressure in the gun, the conditions of safety in handling, and certainty of action are opposing ones.

It was impossible to meet successfully both sets of conditions in all cases, the stress developed in the direction of the axis by accidental dropping of a fuze being in many cases higher than that developed in the gun.

As has been shown, two classes of ring-resistance fuzes are required, the "low resistance" and the "high resistance"; the low resistance for use in the 7-inch mortar, in which piece the low powder pressures impart a low maximum acceleration to the projectile, and require greater sensitiveness in the fuze.

The greater liability to accident in handling fuzed projectiles due to the rapidity of fire required from modern guns, has caused the retirement of fuzes that depend for their action upon the acceleration of the projectile in the gun, except in some of the smaller guns where the acceleration is so great that a very

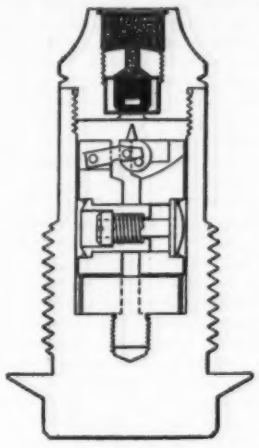


FIG. 22.

high arming resistance can be given. A fuze which is armed by the centrifugal force developed by the rotation of the projectile, and which is safe until the maximum velocity of rotation is nearly attained, has been developed at the Frankford Arsenal, and is now applied to all projectiles above the 6-pounder in caliber.

As already stated, ring-resistance fuzes are used in 1-pounder, 2-pounder, and 6-pounder shell. The limited fuze dimensions render the construction of a satisfactory centrifugal fuze for these shell mechanically very difficult; but, by reason of the high maximum acceleration of these projectiles in the gun, the sensitiveness of the ring-resistance fuzes need not be so great as to interfere with the safe handling of the projectiles.

The centrifugal fuze, before arming, is shown in Fig. 19. Fig. 20 is a view of the plunger after arming.

The fuze body, or stock, and the primer parts of the centrifugal fuze do not differ materially from the corresponding parts of the ring-resistance fuzes. To protect better the priming charge, the closing cap screw *b* is lengthened and the vented primer-closing screw *a* is added.

The body of the centrifugal plunger is in two parts, nearly semi-cylindrical in shape, which, when the

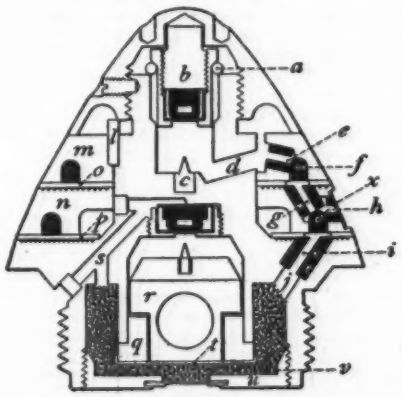



FIG. 23.

fuze is at rest, are held together by the pressure of a spiral spring *g* contained in the cylindrical bushing *e* which is secured to one of the plunger halves. The spring exerts its pressure on the other half of the plunger through the bolt *f*. Pivoted in a recess in one-half of the plunger is the firing pin *d*, which when the fuze is at rest is held with its point below the front surface of the plunger by the lever action of the link *c* which is pivoted in the other half. Under the action of the centrifugal force developed by the rapid rotation of the projectile the two halves of the plunger separate. The separating movement causes the rotation of the firing pin *d*, the point of which is now held in advance of the front surface of the plunger, Fig. 20, ready, on impact of the projectile, to pierce the brass primer shield and ignite the percussion composition. When the fuze is armed the end of the link *c* rests on the axis of the firing pin, thus affording support to the firing pin when it strikes the percussion primer. The separation of the plunger parts is limited by the nut *i* coming to a bearing on a shoulder in the bushing *e*, so as not to permit the diameter of the expanded plunger to equal the interior diameter of fuze stock. See Fig. 22.

A rotating piece, *h*, Fig. 21, screwed into head of fuze stock, engages in a corresponding slot cut through

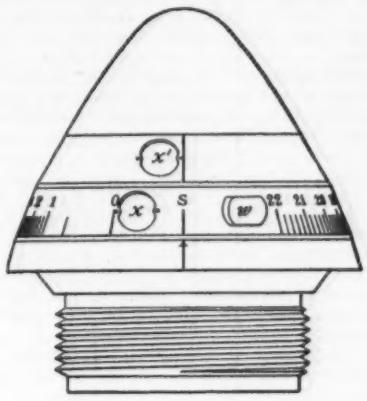



FIG. 24.

the bottom of both plunger-halves and insures rotation of the plunger with the shell.

The strength of the spring *g* is so adjusted that the fuze will not arm until its rapidity of revolution is a certain percentage of that expected in the shell in which it is to be used, and that it will certainly arm when the rapidity of revolution approximates that expected in the shell. Should the parts of the plunger be accidentally separated and the fuze armed by a sudden jolt or jar in transportation or handling, the re-

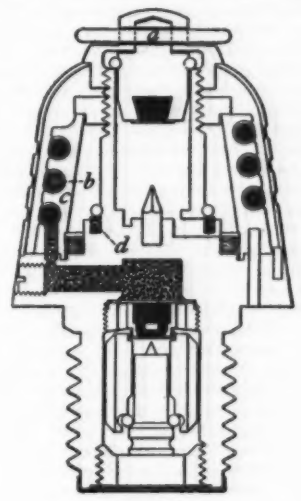



FIG. 25.

action of the spring will immediately bring the plunger to the unarmed condition.

The fuze just described, called *the "F" fuze*, is used in siege detonating fuzes for 5 and 7-inch shell charged with high explosive.

The fuze shown in Fig. 22, the *"S" fuze*, is for use with 3.6 and 7-inch mortar shell, powder-charged, and with the detonating fuzes in 8, 10 and 12-inch armor-piercing projectiles. The additional priming charge

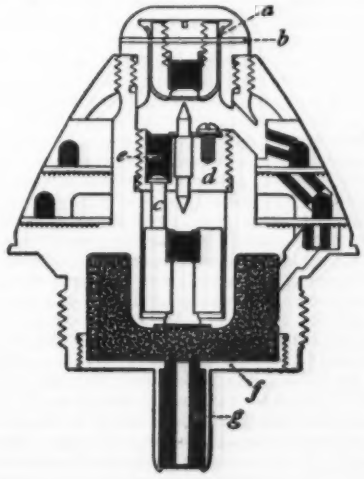



FIG. 26.

in end of fuze gives a greater body of flame than is emitted from the "F" fuze.

A similar fuze of larger size is used in powder-charged shell of 8-inch caliber and over.

A fuze, called the "12 *M*" fuze, is provided for use in detonating fuzes for the 12-inch mortar and torpedo shell. This fuze is similar in construction to the other centrifugal fuzes, but on account of the low velocity of rotation of mortar projectiles and their low striking velocity a much heavier plunger is needed to provide the force necessary for arming the fuze, and for puncturing the primer-shield on impact. In addition, the plunger carries on its front surface a swiveled piece which when the fuze is armed falls into the aperture between the plunger-halves, so that when once armed the two parts of the plunger are automatically locked apart in the armed position. This prevents the closing together of the plunger-halves, and the consequent withdrawal of the firing pin, if the shell should strike upon its side, as it does sometimes when fired at low velocities.

*Combination Fuzes.*—All combination fuzes used in the service are point insertion and combine the elements of time and percussion arranged to act independently in one fuze body.

Combination fuzes contain two plungers and two primers, arming and firing by concussion and percussion respectively.

The concussion plunger arms and fires the concussion primer by shock of discharge in the bore of the piece and ignites the time element. The percussion plunger is armed by the shock of discharge and fires its primer on impact.

There are at present two general classes of com-

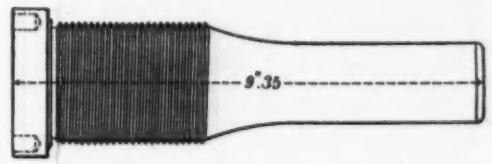



FIG. 27.

bination fuzes in service, differing principally in the details of the time-train elements. In the first class this element consists of a wire-drawn lead tube filled with mealed powder, wound in a spiral groove around a lead cone. In the second class the time element consists of two superposed trains of mealed powder compressed under heavy pressure into annular grooves in disks of brass.

The first class is represented by the following Frankford Arsenal combination fuzes: The 15-second, the 28-second high-resistance, and the 28-second low-resistance combination fuzes. No more fuzes of this class are to be manufactured, and the fuze will become obsolete when the supply now on hand is exhausted.

The second class is represented by the Frankford Arsenal 21-second combination fuze. The method of preparing the time train of this fuze insures much greater uniformity of action than was obtained in the fuze with lead-cased time train. This fuze has, therefore, been adopted for use in service shrapnel.

*Combination Fuze, Latest Pattern.* Fig. 23.—The upper part of the fuze contains the time elements, the lower part the percussion elements. The time elements consist of the concussion or time plunger *b*, the firing pin *c*, and the time train. The firing pin is fixed in the body of the fuze, and the plunger carries the percussion composition and a small igniting charge of black powder. The plunger is held out of contact with the firing pin by the split resistance ring *a*. On the shock of discharge, the inertia of the plunger acting through the conical surface in contact with the split ring expands the ring so that the plunger can pass through it and carry the percussion composition to the firing pin.

The time-train of the fuze is composed of two rings

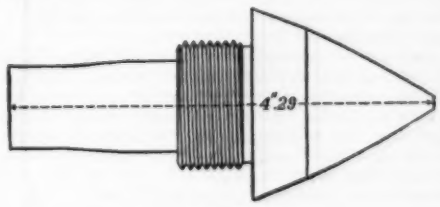



FIG. 28.

of powder *f* and *h* contained in grooves cut in the two time-train rings *m* and *n*. The grooves are not cut completely around the rings, but a solid portion is left between the ends of the groove in each ring. Mealed powder is compressed into the grooves under a pressure of 70,000 pounds per square inch, forming a train 7 inches long, the combined length of the two grooves.

The flame from the percussion composition passes through the vent *d* igniting the compressed tubular powder pellet *e* which in turn ignites one end of the upper time train *f*. When the fuze is set zero the flame passes immediately from the upper time train through the powder pellet *g* to one end of the lower time train *h*; thence through the pellet *i* and vent *j* to the powder *k* in the annular magazine at the base of the fuze.

Under each of the time rings is a felt washer, *o* and *p*, that closes the joint under the ring against the passage of flame, except through the hole in the washer directly over the vent in the part below. The upper washer *o* is glued to the upper corrugated surface of the lower time ring *n* and moves with that ring the lower washer *p* is glued to the fuze body and is stationary. The upper time ring *m* is fixed in position by two pins *l* halved into the fuze body and the ring.

The lower time ring is movable, and any of the graduations on its exterior, see Fig. 24, which correspond to seconds and fifths of seconds of burning, may be brought to the datum line marked on body of fuze below the ring. The ring is moved, in setting, by means of a wrench applied to the projecting stud *w*.

To set the fuze for any time of burning, say 20 seconds, move the lower time ring *n* until the mark 20 is over the datum line. On ignition of the primer the flame ignites the upper time train *f*, which burns clock-wise, looking from base to point of fuze, until the hole through the washer over the zero mark of the lower ring *n* is encountered. The flame then passes through the vent *g* to the lower time train *n*, which burns anti-clockwise until the 20 is reached. This mark being over the vent *i* in the body of fuze, the flame now passes to the magazine *k*. The setting of the fuze consists in fixing the position of the passage from the upper to the lower time train, so as to include a greater or less length of each train between the vent *e* and the vent *i*.

In each time ring a vent opens from the initial end of the powder train to the exterior. The vent contains a pellet of powder and is covered by a thin brass cup. The vent in lower time ring is seen at *x* in Fig. 23. The caps *x*, *x'*, of both vents are shown in Fig. 24. The blowing out of the cap affords a passage to the open air for the flame from the burning time train, thus preventing the bursting of the fuze by the pressure of the contained gases.

When the fuze is set at safety, indicated by the letter *S* stamped on the lower time ring, the position shown in Fig. 24, the solid metal between the ends of the upper time train is over the vent *g* to the lower train, and the solid metal between the ends of the lower train is over the vent *i* leading to the magazine. In case of accidental firing by the time plunger, the upper train will be completely consumed without communicating fire to the lower train and to the magazine. The fuze is habitually carried at this setting, which serves also when it is desired to explode the shell by impact only.

For percussion firing the fuze is provided with a centrifugal plunger *r*, as described in the base percussion fuze. To insure rotation of the plunger with the shell the bottom of the plunger is cut away on the sides to fit in a slot in the rotating ring *q*, which is held firmly against the walls of the plunger-recess by the pressure of the closing screw *u*, screwed down hard. A vent *s* leads from the percussion primer to the annular magazine *k*. A thin brass cap *t* separates the lower plunger-recess from the powder in the four radial chambers *v* cut in the bottom closing screw. The central vent in the closing screw is closed by a piece of shellacked linen, held in place by a brass washer.

These fuzes are issued fixed in the loaded projectiles. For protection in transportation the fuze is covered by a spun brass cap, soldered on to the head of the projectile. The soldering strip is torn off and the cover removed before using the projectile.

*Combination Fuze, Old Pattern.*—The time train *b*, incased in a lead tube, is wound spirally around the lead cone *c*. To set the fuze for any time of burning the time train and lead cone are punctured, by means of a tool provided for the purpose, at the point on the scale marked on the cover of fuze corresponding to the time of burning desired. The puncture passes completely through the time train and the lead cone behind it, forming a channel from the annular space in which the letter *b* appears to the powder in the time train. When the projectile is fired the percussion flame ignites the compressed powder ring *d*, and the flame from this ring ignites the time train at the point at which it has been punctured. The safety pin *a* retains the time plunger in its unarmed position, and must be withdrawn before placing the projectile in the gun. (See Fig. 25.)

*Ehrhardt Combination Fuze.*—This fuze is similar in construction to the Frankford Arsenal fuze, latest pattern, described above, and differs only in details.

The arming of the time plunger of the Ehrhardt fuze, Fig. 26, is resisted by the U-shaped spring *a*, the upper ends of which are sprung out into a counterbored recess in the closing cap, and by the slender brass pin *b*, which passes through the plunger and both sides of the closing cap. At discharge of the piece the inertia of the plunger shears the pin *b* and straightens the U-shaped spring *a*, permitting the plunger to strike the firing pin.

In the percussion mechanism the composition is carried in the plunger and the firing pin is fixed in the diaphragm *d* in body of fuze. The plunger is held away from the firing pin before firing, by the brass restraining pin *c*. The pin is let in to a hole in the diaphragm *d*, the head of the pin abutting against a shoulder near the bottom of the hole. The restraining pellet of powder *e* is pressed in to fill the recess above the pin. A perforated brass disk and a piece of linen close the hole at its upper end and prevent the powder pellet from being jarred out of place. The burning of this pellet on ignition from the time plunger leaves the restraining pin and percussion plunger free to move forward at impact.

A compressed charge of black powder, *g*, is inserted into the extension of the closing screw *f* to re-enforce the magazine charge and effectually to carry the flame to the base charge in the shrapnel.

The Krupp combination fuze does not differ essentially from the Ehrhardt fuze. The shear pin through time plunger is omitted, the U-shaped spring being made strong enough to offer sufficient resistance against accidental arming. The percussion plunger, carrying the percussion composition, is held away from the firing pin, before firing, by a sleeve and an inverted U-shaped resistance spring. A spiral spring between plunger and firing pin prevents the creeping forward of the plunger during the flight of the projectile.

*Detonating Fuzes.*—These fuzes are for use in shell containing high explosives.

Fig. 28 shows the form of detonating fuze for point insertion in field shell. Fig. 27 shows the form of fuze for base insertion in siege and seacoast projectiles.

In order to prevent the unscrewing of the fuze during flight of the projectile, all point insertion fuzes are provided with right-handed screw threads, and base insertion fuzes with left-handed threads.

## PRELIMINARY REPORT OF THE STATE EARTHQUAKE INVESTIGATION COMMISSION.

IT was determined that the scope of the work of the Commission in its preliminary stages should embrace the questions as to the origin, the position, and the character of the disturbance in the earth's crust which gave rise to the earthquake, these questions to be investigated by:

1. The location of fault scarps and other deformations of the surface of the ground or sea bottom in the region affected;

2. The collection of time records leading to the construction of coseismal curves;

3. The collection of intensity records and their classification in a graded scale leading to the construction of isoseismal curves.

It was agreed that the intensity should be considered in its relation to geological formations and structures, and in its relation to man; that the relationship between types of manifestation and the characters of transmitting formations should be studied with the object of determining the cause of relative immunity of certain localities and of violent destruction in others; that in the interpretation of intensity from the destruction of buildings, etc., the character of the structure should be carefully considered.

Having outlined the scope of its work, the Commission appointed two committees, one on isoseismals, Andrew C. Lawson chairman, and one on coseismals, A. O. Leuschner chairman.

Immediately after the earthquake and before the appointment of the Commission, the scientific men of the State had been active in the investigation of the effects of the earthquake, and the appointment of the Commission and the plan of work which it formulated served to organize their efforts and bring the results of their observations together. From the purely scientific point of view, the earthquake of the 18th of April is one of the most interesting on record, and in some respects it is unique. A complete study of the phenomena will undoubtedly contribute greatly not only to our knowledge of the evolution of the earth's crust, but also to our knowledge of the means of minimizing the calamities which arise from the destruction of buildings, water pipes, and other structures, when such shocks occur in the future. Certain of the studies which have this important object in view fall within the province of the structural engineer and the architect, and they have already formulated many suggestions dealing with principles and materials of construction which will be of very great value in the future construction of buildings, not only in San Francisco but in all parts of the country which are subject to earthquake shocks. Other studies having the same beneficent object in view are more properly germane to the purposes of your Commission. These refer chiefly to the relation between destructive effects and the character of the ground and underlying rocks upon which structures stand; and to this question your Commission has given especial attention. It has also had constantly in mind the desirability of discovering evidence upon which a judgment might be based as to the probability of recurrence of the earthquake in the future.

Having thus far outlined the organization of the Commission, its more important official acts, and the scope and plan of its work, a word may be said regarding the methods employed before going on to a statement of the general results attained, and of the problems which remain as yet to be solved. The committee on coseismals, being concerned with the records of the times at which the earthquake was felt, has thus far had to depend largely upon correspondence for its information. The records are of two kinds: first those which are based upon personal observations at the time of the shock, and secondly those which were automatically registered by delicate instruments not only in different parts of the State but also throughout the civilized world. For the latter the committee is under obligations to seismologists in many lands as well as our own. For the purpose of collecting the time records in possession of the citizens of the State based upon their personal observation, the committee on coseismals issued a supplementary circular. In securing replies to the questions set forth in this circular from people in the territory affected who had special opportunities for observing the time of the earthquake accurately, the committee on coseismals was fortunate in being able to avail itself of the hearty co-operation and assistance of various branches of the public service and of the several railroad, telegraph, and telephone companies operating in the State, through their executive officers. Such aid has been notably rendered by the officers of the United States Weather Bureau, the United States Coast and Geodetic Survey, the United States Light-house Service, and several officers of the United States army, and of the navy. The agents and operators of the Southern Pacific Railway, the Atchison, Topeka, and Sante Fe Railway, the California Northwestern Railway, the Western Union Telegraph Company, the Postal Telegraph Company, and the Pacific States Telephone and Telegraph Company, and many teachers in the high schools of the State have all been enlisted in the work of supplying the observed times of the shock in various parts of the State.

The committee on isoseismals has also been greatly assisted by information contributed by citizens of the State in response to inquiries sent out through the press. The numerous replies that have been received indicate a very widespread and intelligent interest in the phenomenon in its purely scientific aspects. But the more important collection of data by this committee has been and is being made by field observation by members of the committee and their aides.

### RESULTS.

One of the remarkable features of the Coast Ranges of California is a line of peculiar geomorphic expression which extends obliquely across the entire width of the mountainous belt from Mendocino County to Riverside County. The peculiarity of the surface features along this line lies in the fact that they are not due, as nearly all the other features of the mountains are, to atmospheric and stream erosion of the uplifted mass which constitutes the mountains, but have been formed by a dislocation of the earth's crust, or rather a series of such dislocations, in time past, with a differential movement of the parts on either side of the plane of rupture. In general this line follows a system of long, narrow valleys, or where it passes through wide valleys it lies close to the base of the confining hills, and these have a very straight trend; in some places, however, it passes over mountain ridges, usually at the divide separating the ends of two valleys; it even in some cases goes over a spur or shoulder of a mountain. Along this line are very commonly found abrupt changes in the normal slope of the valley sides giving rise to what are technically known as scarps. These scarps have the appearance of low precipitous walls which have been usually softened and rounded somewhat by the action of the weather. Small basins or ponds, many having no outlet, and some containing saline water, are of fairly frequent occurrence and they usually lie at the base of the small scarps. Trough-like depressions also occur bounded on both sides by scarps. These troughs and basins can only be explained as due to an actual subsidence of the ground, or to an uplift of the ground on one side or the other, or on both sides. The scarps similarly can only be ascribed to a rupture of the earth with a relative vertical displacement along the rupture plane. Frequently small knolls or sharp little ridges are found to characterize this line and these are bounded on one side by a softened scarp and separated from the normal slope of the valley side by a line of depression. In many cases these features have been so modified and toned down by atmospheric attack that only the expert eye can recognize their abnormal character; but where their line traverses the more desert parts of the Coast Range, as for example in the Carissa Plains, they are well known to the people of the country and the aggregate of the features is commonly referred to as the "earthquake crack."

This line begins on the north at the mouth of Alder Creek near Point Arena and extends southeasterly nearly parallel with the coast line to a point about two miles below Fort Ross, a distance of forty-three miles. Here it passes outside of the shore line and is again met with at the point where Bodega Head joins the mainland. Thence it appears to continue southward through Tomales Bay and Bolinas Lagoon. Beyond Bolinas Lagoon it passes outside of the Golden Gate and enters the shore again at Mussel Rock, eight miles south of the Cliff House. From this point it is traceable continuously along the valley line occupied by San Andreas and Crystal Springs Lakes, past Woodside and Portola, over a saddle back of Black Mountain, thence along Stevens Creek Cañon, passing to the southwest of Table Mountain and Congress Springs to the vicinity of Wrights, on the narrow-gage railway between San José and Santa Cruz. From Wrights it continues on in the same course through Santa Cruz Mountains to the point where the Southern Pacific Railway crosses the Pajaro River near Chittenden. From the crossing of the Pajaro the line extends up the valley of the San Benito River, across the eastern portion of Monterey County, and thence follows the northeastern side of the valley of the San Juan River and the Carissa Plains to the vicinity of Mount Pinos, in Ventura County. The line thus traced from Point Arena to Mount Pinos has a length of 375 miles, is remarkably straight, and cuts obliquely across the entire breadth of the Coast Ranges. To the south of Mount Pinos the line either bends to the eastward following the general curvature of the ranges or is paralleled by a similar offset from it *en echelon;* for similar features are reported at the Tejon Pass and traceable thence though less continuously across the Mojave Desert to Cajon Pass and beyond this to San Jacinto and the southeast border of the Colorado Desert. The probability is that there are two such lines, and that the main line traced from Point Arena to Mount Pinos is continued with the same general straight trend past San Francisco and along the base of the remarkably even fault scarp at the foot of which lies Lake Elsinore. But, leaving the southern extension of the line out of consideration as somewhat

debatable, we have a very remarkable physiographic line extending from Point Arena to Mount Pinos which affords every evidence of having been in past time a rift, or line of dislocation, of the earth's crust and of recurrent differential movement along the plane of rupture. The movements which have taken place along this line extend far back into the Quaternary period, as indicated by the major, well degraded fault scarps and their associated valleys; but they have also occurred in quite recent times, as is indicated by the minor and still undegraded scarps. Probably every movement on this line produced an earthquake, the severity of which was proportionate to the amount of movement.

The cause of these movements in general terms is that stresses are generated in the earth's crust which accumulate till they exceed the strength of the rocks composing the crust and they find a relief in a sudden rupture. This establishes the plane of dislocation in the first instance, and in future movements the stresses have only to accumulate to the point of overcoming the friction on that plane and any cementation that may have been effected in the intervals between movements.

The earthquake of the 18th of April, 1906, was due to one of these movements. The extent of the rift upon which the movement of that date took place is at the time of writing not fully known. It is, however, known from direct field observations that it extends certainly from the mouth of Alder Creek near Point Arena to the vicinity of San Juan in San Benito County, a distance of about 185 miles. The destruction at Petrolia and Ferndale in Humboldt County indicates that the movement on the rift extended at least as far as Cape Mendocino, though whether the rift lies inland or offshore remains as yet a matter of inquiry. Adding the inferred extension of the movement to its observed extent gives us a total length of about three hundred miles. The general trend of this line is about N. 35 deg. W., but in Sonoma and Mendocino counties it appears to have a slight concavity to the northeast, and if this curvature be maintained in its path beneath the waters of the Pacific it would pass very close to and possibly inside of Capes Gordo and Mendocino. Along the 185 miles of this rift where movement has actually been observed the displacement has been chiefly horizontal on a nearly vertical plane, and the country to the southwest of the rift has moved northwesterly relatively to the country on the northeast of the rift. By this it is not intended to imply that the northeast side was passive and the southwest side active in the movement. Most probably the two sides moved in opposite directions. The evidence of the rupture and of the differential movement along the line of rift is very clear and unequivocal. The surface soil presents a continuous furrow generally several feet wide with transverse cracks which show very plainly the effort of torsion within the zone of the movement. All fences, roads, stream courses, pipe lines, dams, conduits, and property lines which cross the rift are dislocated. The amount of dislocation varies. In several instances observed it does not exceed six feet. A more common measurement is eight to ten feet. In some cases as much as fifteen or sixteen feet of horizontal displacement has been observed, while in one case a roadway was found to have been differentially moved twenty feet. Probably the mean value for the amount of horizontal displacement along the rift line is about ten feet and the variations from this are due to local causes such as drag of the mantle of soil upon the rocks, or the excessive movement of soft incoherent deposits. Besides this general horizontal displacement of about ten feet there is observable in Sonoma and Mendocino counties a differential vertical movement not exceeding four feet, so far as at present known, whereby the southwest side of the rift was raised relatively to the northeast side, so as to present a low scarp facing the northeast. This vertical movement diminishes to the southeast along the rift line and in San Mateo County is scarcely if at all observable. Still farther south there are suggestions that this movement may have been in the reverse direction, but this needs further field study.

As a consequence of the movement it is probable that the latitudes and longitudes of all points in the Coast Ranges have been permanently changed a few feet, and that the stations occupied by the Coast and Geodetic Survey in their triangulation work have been changed in position. It is hoped that a reoccupation of some of these stations by the Coast and Geodetic Survey may contribute data to the final estimate of the amount of movement.

The great length of the rift upon which movement has occurred makes this earthquake unique. Such length implies great depth of rupture, and the study of the question of depth will, it is believed, contribute much to current geophysical conceptions.

The time of the beginning of the earthquake as recorded in the observatory at Berkeley was 5h. 12m. 6s. A. M., Pacific standard time. The end of the shock was 5h. 13m. 11s. A. M., the duration being 1m. 5s. Within an hour of the main shock twelve minor shocks were observed by Mr. S. Albrecht of the Observatory and their time accurately noted. Before 6h. 52m. P. M. of the same day thirty-one shocks were noted in addition to the main disturbance. These minor shocks continued for many days after April 18, and in this respect the earthquake accords in behavior with other notable earthquakes in the past. The minor shocks which succeed the main one are interpreted generally as due to subordinate adjustments of the earth's crust in the tendency to reach equilibrium after the chief movement.

The collection of time records necessarily proceeds slowly. The purpose of the coseismal curves based upon these records is in general two-fold. In ordinary earthquakes it is one of the means of locating the seat of the disturbance when there is no surface manifestation of the rupture in the earth's crust. In the present instance, however, the rupture has declared itself in an unmistakable rift observable at the surface, and coseismals are therefore unnecessary for the determination of this important factor in the general problem, so far at least as regards the main disturbance. It is probable, however, that so radical a change in the equilibrium of the stresses of the earth's crust would induce secondary ruptures and consequently secondary earthquakes closely associated with the chief shock. The careful plotting of the time records may, therefore, be useful in revealing the location of these secondary disturbances, such for example as the one which affected Southern California on the afternoon of the 18th of April. The second purpose of securing time records is the determination of the velocity of propagation of the earth wave; and the data for this which are likely to be most serviceable are the records obtained at various quite distant seismographic stations.

The destructive effects of the earthquake are in the main distributed with reference to the line of rift. The exact limits of the area of destruction have not yet been mapped, but it is known to extend out about twenty-five or possibly thirty miles on either side of the rift. On the southwest side the greater part of this area to the north of the Golden Gate lies in the Pacific. This area extends from Eureka in Humboldt County to the southern extremity of Fresno County, a distance of about four hundred miles.

Beyond this area of destructive shock the earthquake was felt in its milder manifestations over a wide territory. Our reports to date show that it was felt in Oregon as far north as Coos Bay and on the south as far as Los Angeles. To the east it was felt over the greater part of middle California and eastern Nevada, particularly along the eastern flank of the Sierra Nevada. It was felt at Lovelocks, and we have unconfirmed reports of its having been felt at Winnemucca. Far beyond the region within which it was apparent to the senses, however, the earth wave was propagated both through the earth and around its periphery; and some of the most valuable and most accurate records of the disturbance which we have are those which were registered at such distant seismographic stations as Washington, D. C.; Sitka, Alaska; Potsdam, Germany, and Tokyo, Japan.

Within the area of destructive effects approximately 400 by 50 miles in extent the intensity varied greatly. There was a maximum immediately on the rift line. Water pipes, conduits, and bridges crossing this line were rent asunder. Trees were uprooted and thrown to the ground in large numbers. Some trees were snapped off, leaving their stumps standing, and others were split from the roots up. Buildings and other structures were in general violently thrown and otherwise wrecked, though some escaped with but slight damage. Fissures opened in the earth and closed again, and in one case reported a cow was engulfed. A second line of maximum destruction lies along the floor of the valley system of which the Bay of San Francisco is the most notable feature, and particularly in the Santa Rosa and Santa Clara valleys. Santa Rosa, situated twenty miles from the rift, was the most severely shaken town in the State and suffered the greatest disaster relatively to its population and extent. Healdsburg suffered to a nearly similar degree. San José, situated thirteen miles, and Agnews, about twelve miles from the rift, are next in the order of severity. Stanford University, seven miles from the rift, is probably to be placed in the same category. All of these places are situated on the valley floor and are underlain to a considerable depth by loose or but slightly coherent geological formations, and their position strongly suggests that the earth waves as propagated by such formations are much more destructive than the waves which are propagated by the firmer and highly elastic rocks of the adjoining hill lands. This suggestion is supported by a consideration of the destructive effects exhibited by towns and single buildings along the same valley line which are situated wholly or partly on rock. Petaluma and San Rafael, though nearer the rift than Santa Rosa, suffered notably less, and they are for the most part on, or close to, the rocky surface. The portions of Berkeley and Oakland which are situated on the alluvial slope suffered more than the foothills, where the buildings are founded on rock. The same suggestion is further supported from a consideration of the zone of maximum destructive effect on the southwest side of the rift. This zone lies in the Salinas Valley. The intensity of destructive action at Salinas was about the same as at San José, and the town is situated on the flood plain deposits of the Salinas River. Along the banks of the Salinas River and extending from Salinas to the vicinity of Gonzales, so far as our reports at present show, the bottom lands were more severely ruptured, fissured, and otherwise deformed than in any other portion of the State. The Spreckels sugar mill, situated on the banks of the river, suffered more severely probably than any other steel structure in the State. Santa Cruz, on the other hand, which is on the same side of the rift, and at the same distance from it, but which is built on rock for the most part, suffered much less damage. In the northern counties along the coast the most severe effects were felt at Ferndale, on the south margin of the flood plain of the Eel River, and at Petrolia, on the bottom land of the Mattole. Fort Bragg was severely shaken with very destructive effects, but our reports do not yet indicate the character of the ground upon which it is situated.

In the facts which have been cited we seem to have warrant for a generalization as to the excessively destructive effect of the earth wave as transmitted by the little coherent formations of the valley bottoms. But it must be borne in mind that by far the greater number of structures subject to destructive shock are situated in the valley lands and that there has not yet been time for a detailed comparison of the effects in the valleys with those in the hills, where the buildings are founded on firm rock except in a few notable instances.

The most instructive of these instances is the city of San Francisco, and the facts observed there are entirely in harmony with the generalization above outlined. In the city of San Francisco we may recogize for preliminary purposes four types of ground: (1) The rocky hill slopes; (2) the valleys between the spurs of the hills which have been filled in slowly by natural processes; (3) the sand dunes; (4) the artificially filled land on the fringe of the city. Throughout the city we have a graded scale of intensity of destructive effects which corresponds closely to this classification of the ground. The most violent destruction of buildings, as everybody knows, was on the made ground. This ground seems to have behaved during the earthquake very much in the same way as jelly in a bowl, or as a semi-liquid material in a tank. The earth waves which pass through the highly elastic rocks swiftly with a small amplitude seem in this material to have been transformed into slow undulations of great amplitude which were excessively destructive. The filled-in material and the swampy foundation upon which it rests behaved, in other words, as a mass superimposed upon the earth's surface, rather than as a part of the elastic crust itself. In a less degree the same thing is true of the sand dune areas, where the ground was frequently deformed and fissured. In still less degree the naturally filled valleys between the hill spurs were susceptible to this kind of movement, and the destruction of buildings was correspondingly less, but still severe, depending very largely on the character of the buildings, the integrity of their construction, etc. In portions of these valleys, however, the original surface of the ground has been modified by grading and filling, and on the filled areas the destruction was more thorough than elsewhere in the same valley tracts. On the rocky slopes and ridge tops, where, for the most part, the vibration communicated to buildings was that of the elastic underlying rocks, the destruction was at a minimum. On some of the hills chimneys fell very generally and walls were cracked; on others even the chimneys withstood the shock.

While this correlation of intensity of destructive effect appears to hold as a generalization, there are well-known exceptions which find their explanation in the strength of the structures. Modern class A steel structures with deep foundations appear to have been relatively passive, while the made ground in their immediate vicinity was profoundly disturbed. Thoroughly bonded and well cemented brick structures, on similarly deep and solid foundations, seem to have been equally competent to withstand the shock, except for occasional pier-like walls not well tied to the rest of the building. The weak points in wooden frame structures were in general the faulty underpinning and lack of bracing, and chimneys entirely unadapted to resist such shocks. With these faults corrected, frame buildings of honest construction would suffer little damage beyond cracking of plaster in such a shock as the 18th of April, save on the made ground, where deep foundations and large mass appear to be essential for the necessary degree of passivity.

Pipe lines and bridges crossing the rift line present a peculiar, if not quite unique, engineering problem which will doubtless be solved in the near future. Pipe lines on low, swampy ground or in made ground are in much greater danger of destruction from earthquake shocks than those on high ground underlaid by rock, except in the immediate vicinity of the rift, where nothing could be constructed which would withstand the violence of the earth movement.

One of the lessons of the earthquake which seems peculiarly impressive is the necessity for studying carefully the site of proposed costly public buildings where large numbers of people are likely to be congregated. In so far as possible such sites should be selected on slopes upon which sound rock foundation can be reached. It is probably in large measure due to the fact of their having such a rock foundation that the buildings of the State University, at Berkeley, escaped practically uninjured. The construction of such buildings as our public schools demands the most earnest attention of the people and of the authorities charged with their construction. A great many of our schools proved to be of flimsy construction and ill adapted to meet the emergency of an earthquake shock of even less severity than that of the 18th of April.

The Commission in presenting this brief report has had in mind the demand on the part of the people of the State and of the world at large for reliable information as to the essential facts of the earthquake. It has, therefore, not presumed to engage in any discussion of the more abstruse geological questions which the event naturally raises. It leaves such discussion for a more exhaustive report which can only be pre-

pared after the campaign of data collection is complete, and that may be some months hence.

A. O. LEUSCHNER, Secretary. ANDREW C. LAWSON, Chairman.

## TRADE NOTES AND FORMULÆ.

**To Render Wooden Receptacles Durable.**—To make wooden vessels durable and prevent the penetration of liquids into the pores with attendant destruction of the wood, a resin varnish consisting of shellac 1,000 parts by weight, resin 125 parts, Venice turpentine 125 parts, and alcohol 6,000 parts, has been found valuable. The resins are melted together and the alcohol poured over the molten substance while still liquid. For wooden receptacles destined to contain hot liquid this coating does not answer, since the varnish commences to soften at 70 deg. C. (158 deg. F.).—Deutsche Destillateur Zeitung.

**Simple Test for Files.**—To test two flat files for their relative sharpness lay a small block of metal on the first, then upon the second, and try at what angle the file can be held without the sliding off of the block. The file which can be held at the greater angle is of course the sharper of the two.—Metallarbeiter.

**Artificial Rubber.**—According to the Tropenpflanzer, the production of artificial rubber is carried out as follows: Treat 30 to 30 parts by weight of Carragheen moss at 80 deg. to 90 deg. C. (176 deg. to 194 deg. F.) with 1,000 parts water until all slime has been extracted. After the solution has been freed from suspended particles, 100 to 200 parts of starch are added, the starch having previously been ground in water. The mixture is applied on slightly oiled metal plates in a thin layer and dried below 100 deg. C. (212 deg. F.). Upon drying the product constitutes a colorless skin which is broken to pieces. In cold water the product softens, and forms upon subsequent heating a thick gummy substance which may be employed as a thickening agent in paint or as a substitute for rubber.

**Quick Drying of Negatives.**—As is well known, negatives can be dried in a short time (five minutes) by placing them in alcohol. If it is desired to dry a large number of negatives rapidly the use of three receptacles of alcohol is recommended. The negative is first placed in dish No. 1, left therein for five minutes; then in dish No. 2, and so on. When withdrawn from the third dish, it will be almost perfectly dry in the air. In this manner the alcohol remains useful much longer, but is finally also weakened from the absorption of water. Then the contents of the three dishes are poured together into a vessel, adding a dehydrating agent, such as calcium chloride, and shaken. The latter absorbs the water and retains it. —Wiener Mitteilungen.

**Asbestos Porcelain.**—This is the name given by Garros to a substance originated by him, which in every particular equals the properties of porcelain, over which it possesses several advantages. Asbestos fibers are very thin, their diameter varying from 0.00016 to 0.0002 millimeter, so that an exceedingly fine powder can be obtained from them. This powder is mixed with water, to form a paste, which is kneaded, again mixed with water, dried, kneaded once more, and finally poured into suitable molds. By heating the objects in a crucible to a temperature of 1,700 deg. C. a product resembling ordinary porcelain as regards transparency is obtained. If the same is heated for 18 hours at a temperature of 1,200 deg. C. a porous asbestos porcelain of pale yellowish or white color results if care is taken to wash the powder previously with sulphuric acid.—Neueste Erfindungen.

**Waterproof Composition for Harness.**—This formula is designed for large quantities, but the proportions can be reduced for less amounts. Melt together 5.450 parts of resin with 16.38 parts of paraffine in scales, and add 13.50 parts of mineral oil; stir the whole into 27.25 liters of oil of turpentine. While stirring, pour into the mixture 5.45 parts of brown syrup, then 7.94 parts of lamp black, 2.5 parts of naphthaline black, 0.68 part of Berlin blue, and complete the preparation with 0.17 part of mirbane essence for perfume.—Journal für Praktische Chemie.

**To Protect Metal from Atmospheric Influence.**—A varnish, obtained by dissolving wax in turpentine, is recommended for this purpose, but it damages the surfaces covered with it if they have delicate ornaments. A better varnish is made of 15 parts by weight of shellac, 13 parts of Siam benzoin gum, 80 parts of alcohol, and 20 parts of formyl chloride; the last facilitates the dissolution of the resin.—Zeitschrift für Krystallographie und Mineralogie.

**Varnish for Furniture.**—In 52 parts of alcohol dissolve 4 parts of shellac. On the other hand, dissolve the same quantity of boiled linseed oil in 16 parts of oil of turpentine. Mix the two solutions slowly, while stirring constantly. Finally, add 4 parts of liquid ammonia, and mix vigorously to render the whole perfectly homogeneous.—Chemiker Zeitung.

**Compound Perfume.**—This is sold under the name of nuptial bouquet. The following is the recipe: Mix 120 parts of oil of rose, the same quantity of oil of jasmin and the same of the quadruple extract of orange flowers, 30 parts of vanilla oil, 60 parts of musk oil and the same quantity of the tincture of gum styrax, completing the whole with 30 drops of sandal oil. The tincture of the gum styrax is prepared with alcohol of 90 per cent and liquid styrax, in the proportion 1 of the latter to 20 of alcohol.—Journal de la Parfumerie et Savonnerie.


*Instructive*

**Scientific Papers**

**On Timely Topics**

**Price 10 Cents each, by mail**

**ARTIFICIAL STONE.** By L. P. Ford. A paper of immense practical value to the architect and builder. SCIENTIFIC AMERICAN SUPPLEMENT **1500.**

**THE SHRINKAGE AND WARPING OF TIMBER.** By Harold Busbridge. An excellent presentation of modern views; fully illustrated. SCIENTIFIC AMERICAN SUPPLEMENT **1500.**

**CONSTRUCTION OF AN INDICATING OR RECORDING TIN PLATE ANEROID BAROMETER.** By N. Monroe Hopkins. Fully illustrated. SCIENTIFIC AMERICAN SUPPLEMENT **1500.**

**DIRECT-VISION SPECTROSCOPES.** By T. H. Blakesley, M.A. An admirably written, instructive and copiously illustrated article. SCIENTIFIC AMERICAN SUPPLEMENT **1493.**

**HOME MADE DYNAMOS.** SCIENTIFIC AMERICAN SUPPLEMENTS **161** and **600** contain excellent articles with full drawings.

**PLATING DYNAMOS.** SCIENTIFIC AMERICAN SUPPLEMENTS **720** and **793** describe their construction so clearly that any amateur can make them.

**DYNAMO AND MOTOR COMBINED.** Fully described and illustrated in SCIENTIFIC AMERICAN SUPPLEMENTS **844** and **865.** The machines can be run either as dynamos or motors.

**ELECTRICAL MOTORS.** Their construction at home. SCIENTIFIC AMERICAN SUPPLEMENTS **759, 761, 767, 641.**

**THE MAKING OF A DRY BATTERY.** SCIENTIFIC AMERICAN SUPPLEMENTS **1001, 1387, 1383.** Invaluable for experimental students.

**ELECTRICAL FURNACES** are fully described in SCIENTIFIC AMERICAN SUPPLEMENTS **1152, 1107, 1374, 1375, 1419, 1420, 1421, 1077.**

**MODERN METHODS OF STEEL CASTING.** By Joseph Horner. A highly instructive paper; fully illustrated. SCIENTIFIC AMERICAN SUPPLEMENTS **1503** and **1504.**

**THE CONSTITUTION OF PORTLAND CEMENT FROM A CHEMICAL AND PHYSICAL STANDPOINT.** By Clifford Richardson. SCIENTIFIC AMERICAN SUPPLEMENTS **1510** and **1511.**

**Price 10 Cents each, by mail**

Order through your newsdealer or from

**MUNN & COMPANY**

**361 Broadway** **New York**



**THE**

**Scientific American Supplement.**

**PUBLISHED WEEKLY.**

**Terms of Subscription, $5 a year.**

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

**MUNN & CO., Publishers,**

**361 Broadway, New York, N. Y.**


## TABLE OF CONTENTS.


PAGE

I. CIVIL ENGINEERING.—Canals, Ancient and Modern.—II... 25473
Engineering Notes..... 25479

II. ELECTRICITY.—Contemporary Electrical Science..... 25471
Control of the Direction of Electric Waves.—By WILLIAM MARCONI, LL.D., D.Sc.—8 illustrations..... 25478
Devices for Determining the Energy Losses in Iron Sheets.—By Dr. ALFRED GRADENWITZ.—7 illustrations..... 25477
Rotary Converter Sub-stations of the Long Island Railroad.—7 illustrations..... 25476

III. GEOLOGY.—Preliminary Report of the State Earthquake Commission..... 25482

IV. MECHANICAL ENGINEERING.—Gas Engines for Ship Propulsion.—II.—By J. E. THORNYCROFT.—3 illustrations..... 25479

V. MINING AND METALLURGY.—The Metals in Human Progress.—II.—By NELSON P. HULST..... 25474

VI. MISCELLANEOUS.—Foreign Commerce of United States..... 25475
Trade Notes and Formulæ..... 25484

VII. ORDNANCE.—Primers and Fuzes for Cannon.—II.—By Major ORMOND M. LISSAK.—14 illustrations..... 25480

VIII. TECHNOLOGY.—Gypsum—A Much Misunderstood Material.—By ROBERT GRIMSHAW..... 25476
Tinning..... 25471
White Cements..... 25479

IX. ZOOLOGY.—The Mud-skipper or Jumping Fish.—By RANDOLPH I. GEARE.—1 illustration..... 25476

**768 Pages**
**556 Illustrations**

**Price $3.50**
**Postpaid**

**Electricians' Handy Book**

**A MODERN WORK OF REFERENCE**

**A COMPENDIUM OF USEFUL DATA, COVERING THE FIELD OF ELECTRICAL ENGINEERING**

Including The Theory of the Electric Current and Circuit, Electro-Chemistry, Primary Batteries, Storage Batteries, Generation and Utilization of Electric Power, Alternating Current, Armature Winding, Dynamos and Motors, Motor Generators, Operation of the Central Station, Switchboards, Safety Appliances, Distribution of Electric Light and Power, Street Mains, Transformers, Arc and Incandescent Lighting, Electric Measurements, Photometry, Electric Railways, Telephony, Bell-Wiring, Electro-Plating, Electric Heating, Wireless Telegraphy, Etc., Etc., Etc.

*Containing 556 Illustrations and Diagrams*

**By T. O'CONOR SLOANE, A.M., E.M., Ph.D.**

**Handsomely Bound in Red Leather, with Titles and Edges in Gold, Pocket Book Style . . .**

☞ *Special circular of contents free.*

**MUNN & COMPANY, Publishers**

**361 Broadway, New York City**

t.

any
rs a

the
, 10

like-
arly.
3.50

ICAN
one

and

Y.

PAGE
25473
25479
25471
25478
25477
25480
25488
25479
25474
25475
25484
25480
25476
25471
25479
25476